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TECHNICAL BULLETINS

COLLEGE OF AGRICULTURE, AGRICULTURAL EXPERIMENT STATION

ENTOMOLOGY

Vol. I, No. 1, pp. 1-152. September, 1906

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BY

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FEB 14 1907
289684

SACRAMENTO:
W. W. SHANNON, - - SUPT. STATE PRINTING.
1906

UNIVERSITY OF CALIFORNIA PUBLICATIONS
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CONTRIBUTIONS FROM THE ZOOLOGICAL LABORATORY OF THE MUSEUM OF COMPARATIVE ZOOLOGY AT HARVARD COLLEGE, UNDER THE DIRECTION OF E. L. MARK.—No. 181.

THE WING VEINS OF INSECTS.

BY

C. W. WOODWORTH.

INTRODUCTION.

The wings of insects are more extensively used in classification than any other portion of the body. Since wing characters are peculiarly conspicuous and tangible, it might be supposed that taxonomists have chosen them for the identification of groups to a larger extent than their relative importance warrants, simply because they present easily recognized characters. One has but to make comparison, however, of wing characters with those based on other parts of the body to be led irresistibly to the conclusion that they are of exceptionally high value. It is not too much to say that of all structures the wings have preserved the most nearly complete record of the course of the phyletic history of insects. The confidence with which wing characters are selected for the differentiation of groups results, in large part, from the recognition of this high phylogenetic significance, and the conviction that groups so defined are natural.

Though this fact will doubtless be readily conceded by every one, it seems strange that so little attention has been given to the study of the wings by those who have attempted to investigate the classification of the orders of insects from the standpoint of their evolution. There is, however, a difficulty which has stood, and still stands, in the way of the utilization of the data, that may be a sufficient explanation of this failure. It is the absence of a really comprehensive study of this compli-

cated subject. The complexity arises from the plasticity of the organ upon which its value for systematic and phyletic purpose depends,—a plasticity that permits the minute differences between species or varieties to record themselves, thus making the older history so nearly illegible that one is hardly to be criticised if he despair of deciphering it.

Aside from the color-pattern,—a matter scarcely ever of more than generic value, and usually less,—the venation of the wing includes practically every item that has been found useful in classification based on that organ. We must turn, therefore, to the study of venation for the evidence afforded by the wings upon the questions of their origin and the relationship between the larger groups of insects.

The important contributions that have been made to the study of venation may be put into three quite distinct groups, corresponding to the motive, or point of view, of the investigator. By far the largest number of authorities on venation are the systematists, or the students of single groups, who have in most cases ignored similar work by fellow laborers in other groups, the result being an almost unendurable confusion of nomenclature. It should be said, however, that we owe to them a most careful elaboration of the details and in almost every case a trustworthy establishment of homologies within the groups upon which they labored. We shall here mention only some of the most conspicuous authors from the almost endless list of those who have studied along this line. Among those most worthy of mention, on account of the quality, extent, or significance of their contributions, are De Selys Longchamp (Odonata); Eaton (Ephemeridæ); Hagen, Wood-Mason (Embidæ); Hagen, Kolbe, MacLaughlin, Spangberg (Psocidæ); Brunner von Wattenwyl (Orthoptera); Fieber, Kolenati (Hemiptera); Heer, Kirby, Kempers (Coleoptera); MacLaughlin (Phryganæidæ); Löw, Meigen, Schiner (Diptera); Forster, Schenk, Shuckard, Thompson (Hymenoptera); Comstock, Packard, and Spuler (Lepidoptera). The second group are the paleontologists, three of whom have made very valuable and extensive studies on the venation of the wings of recent insects, as a means of laying a foundation for their work on fossil forms. They are Brongniart, Heer, and Scudder.

The most important studies of a general nature, besides those of the authors just noted, are those dealing with the

subject from the standpoint of comparative anatomy, the aim being to establish a sound nomenclature. Among these are Adolph, Amans, Brauer, Comstock, Needham, and Redtenbacher.

The result of all this work is that there has been a more exhaustive study of the wings than of any other part of the insect's anatomy. Thousands of species, representing every group of any importance, have been illustrated. The details of the subject can be said to have been very fully worked out, but on the theoretical side not much progress has been made. Most of the theories that have been proposed have been of limited application, relating generally to small matters of special adaptations.

What most needs to be done is to develop a general theory of venation that will serve in the interpretation of the facts that have been so richly accumulated. The present work is an attempt in this direction. The studies of the author have been under way since 1884, and have included the study of microscopical preparations of the wings of about two thousand species representing all the principal groups, the examination of a much larger series of insects with spread wings, and the inspection of practically all the published figures of insect wings. Representatives of most of the larger groups have been studied in their earlier stages, both from simple microscopical preparations of wingpads and from sections. It will not be useful to attempt to present the mass of material thus accumulated, as much of it would of necessity be but the verification of work already well done by others, or the criticism of relatively insignificant details.

The author desires to acknowledge the inspiration and encouragement of Professors Burrill and Forbes of the University of Illinois, with whom his first work on this subject was begun, and the invaluable assistance and advice of that honored and lamented prince of entomologists, Dr. Hagen, whose invariable kindness during the two years' work in his laboratory can never be forgotten; to Dr. Mark, with whom the concluding work has been done, his indebtedness is fully as great; to numerous entomologists, who have aided him with material, and to his students and assistants, especially for the making of preparations, his thanks are due; he regrets that he can not mention them all by name.

PART I.—WINGS.

ORIGIN OF WINGS.

The wings in insects that have simple metamorphosis very evidently arise as outgrowths of the body wall of the thorax, as has been well understood by all entomologists, and described by even the oldest writers. Their development in the higher orders, however, is much more obscure, though the presence of the wing rudiments beneath the skin of the larvæ in the higher insects has been known since the days of Swammerdam (1737–38). The earlier authors quite naturally considered these latter to be entirely different in structure and origin from the wingpads of the lower insects. Weismann ('66) was the first to discover the connection between these internal wing rudiments and the hypodermis of the body wall, but even he believed this to be true only in certain insects (Nematocera). Later, Künckel d'Herculais ('75) showed that, in the groups supposed by Weismann not to have the fundaments of the wings connected with the hypodermis, there was, nevertheless, evidence of such an origin. All subsequent authors who have investigated the subject, with the exception of Landois ('74), Ganin ('76), and Graber ('89), have accepted the idea of the hypodermal origin; as no one of these three were able to discover any other source, all the positive evidence is to the effect that the wings in all the groups, those with complex metamorphosis as well as the others, arise as a modification of the cells of the hypodermis of the thorax.

From this ontogenetic fact the conclusion can be drawn with much confidence that, in the primitive insects also, the wings arise as outgrowths of previously undifferentiated portions of the hypodermis of the thoracic segments. To some extent, especially in the lower insects, as will be shown hereafter, the ontogeny does not exhibit a direct development toward the imaginal wing. There is a great deal of evidence, as will also be shown below, to the effect that the wing in its first development followed likewise an indirect course; that is, in passing from the first differentiation of the skin structure to that found in a perfected wing, the cells assumed functions and developed

peculiarities quite different from those which they at first possessed or finally acquired. From whichever point of view we approach the subject, the evidence points clearly to the truth of this contention.

On the grounds of the need of continuous utility in an organ that is being developed, we must conclude that before it served as a wing it must have existed for some other purpose and owed its structural peculiarities to other functional necessities, since in order to have the slightest value for flight it must have already attained a very considerable size and developed peculiarities both in its own structure and in that of the segment from which it arises. The size requirement has been admitted by all since Gegenbaur ('70) put forth his theory of the origin of wings, but the other requirements of the function of flight have been quite overlooked.

Additional evidence in favor of the theory of the indirect development of the wings may be had from a study of the structure of existing and fossil wings. The great difference that is evident between the structure of the wing membrane and that of the body wall is nowhere bridged over by transitional conditions, even in degenerate and functionless wings. It is only in cases where the wing loses in a measure its flight function by taking upon itself other duties, as in the case of elytra, halters, etc., that the histological structure becomes approximately that of the body wall. The invariable association of strikingly distinct structural peculiarities with the function of flight and the absence of transitional conditions indicates that the primitive wing must have arisen from an organ distinct in function and structure from any of the types of functional wings known in living insects or preserved to us in the rocks. Some of the differentiations that characterize wings arose while the wing exercised this other function.

Finally, the mechanics of the growth of the wing, as far as we can judge, indicate that there are no influences that are able to transform directly an unmodified epithelial cell of the body wall into one capable of producing, for instance, a section of a wing membrane, without passing through a certain course of development by exposure to such conditions as are presented in the wingpad of a nymph. This matter will be discussed more fully when treating of the development of the wing. According to this view the wingpad may be considered

not only a preparation chamber for the wing, but also as representing a vestige of that organ within which the character of the primitive wing is supposed to have been established.

The evidence as to the nature of this hypothetical precursor of the wing has been but little discussed. The usually accepted idea, that of Gegenbaur ('70), is that the wings are modified tracheal gills. Plateau ('71) considers the wings as hypertrophied spiracles, but since he probably holds the same view as to tracheal gills, his theory is not essentially different from the former. Müller ('75), Pancritius ('84), and Packard ('98) are the only writers who have combated this theory. Müller, from his study of the development of the wings in *Calotermes*, concluded that they first arose in the same way as they appear to develop in this young white-ant; that is, as lateral outgrowths of the dorsum. The chief ground for this conclusion was the absence of the tracheæ in the wing fundaments for some time after these make their appearance. Müller contended that this disproved their having been derived from tracheal gills.

Pancritius follows Müller, and adds the idea that the primitive outgrowth of the body wall may have developed into a protective body-covering like an elytron, and that this may have been so modified as to become a wing.

Packard originally adopted the view of Gegenbaur, but in his later work (Packard, '98) accepts in its place the theory of Müller, and attempts to supplement it by outlining what he considers to have been the probable course of development of the wing. According to this modification of the Müllerian hypothesis the primitive winged insect is supposed to have possessed the power of leaping and had lateral extensions of the thoracic segments, which acted as aëroplanes; later, in some manner not explained, these aëroplanes became articulated, were invaded by tracheæ, and finally, after the repression of the organ in the earlier stages of the insect's development, gave rise to true imaginal flying organs.

The grounds upon which Gegenbaur's theory is rejected by Packard are:

First, that tracheal gills are produced in a variety of situations, and not in a definite place like the wings:

Secondly, that a gill is always supplied by a single trachea, a wing by five or six;

Thirdly, that tracheal gills are known only in Neuroptera

and Pseudoneuroptera, and are, therefore, supposed by him to be secondary adaptations, as he seems to doubt that these orders represent the primitive insects.

In answer to these arguments it may be admitted that the tracheal gills are of many sorts, and are not necessarily homologous structures in any strict sense. Gegenbaur did not suggest that the wings arose from organs extending from the end of the abdomen, or from those growing on the base of the legs, but rather that there are tracheal gills on the sides of the abdominal segments, which by their position and structure suggest that other similar, perhaps homologous, structures situated on the corresponding part of the thoracic segments might have been modified into wings. The second argument can be easily disposed of by citing the recent work of Comstock and Needham ('98–99), where it is shown that the wing tracheæ all arise from the side of a single trunk, or at most from two. The weight of any argument based on the arrangement of the tracheæ is greatly diminished by the fact that, in many wings at least, the tracheation is a comparatively late and entirely secondary matter. The final argument advanced by Packard does not seem to have much force. Granting that none of the groups now existing represents the one in which wings first arose, and that tracheal gills as they now occur are always adaptive and secondary, or even that this was true in the primitive insects, it is hard to see any bearing the facts would have on the question at issue.

It is not difficult to find weakness in the ideas advanced by Packard. What, for instance, can be supposed to account for the first development of broad lateral expansions on the sides of the body in ancient Paleozoic times? Certainly these were not developed as a means of protection from the kinds of enemies that are supposed now to account for such structures. Again, there is much more difficulty trying to imagine the process of the conversion of a plate of this nature into a wing than to imagine one produced from such a structure as a tracheal gill; and further, there is no evidence that leaping insects existed in those early times—certainly the remains of jumping insects from the Paleozoic era are not abundant, and the family groups possessing this power have never been recognized as ancestral.

Pancritius's suggestion is open to the same criticism as that

just made. The paleontological evidence is all to the effect that no true elytriferous insects occurred till after the Paleozoic era. The cockroaches of the oldest strata, for instance, still possess comparatively membranous fore-wings.

Müller's theory thus seems not to have been particularly strengthened by these contributions, and really rests on the original ontogenetic observations. Unless other facts can be discovered that will give undoubted support to this theory, it certainly has no sound foundation, for the well-known tendency toward short cuts in ontogeny will easily account for the facts observed by Müller in regard to the tracheation of the young wingpads in *Calotermes*.

Gegenbaur's theory stands, therefore, not only as the generally accepted one, but as a theory against which no very significant objection has been raised, nor has it an important rival. There are grounds, however, more important than any that have been raised, for objecting to this theory in its original and usually accepted form. It may safely be said that the histological conditions essential to the function of blood aëration are far different from such as would be necessary in the construction of an organ of flight. A wing could not have been directly produced from a tracheal gill. The changes that must occur in the production of a wing are so great as to require, as an intermediate stage, the modification of the gill into an organ with a different function.

When an organ changes from one structure and function to another it must be possible for the organ to serve for a while the former function, but there must also be requirements in the first function that will cause a development of the organ to a stage where it can serve also in the new function.

In no tracheal gill not specialized somewhat for some other than the primary function is there a sufficient approach either in size, form, or structure toward an organ that could assume in the slightest degree the function of flight. It seems necessary for this reason to modify Gegenbaur's theory, as has been done by Lang ('88), so as to recognize the tracheal gill as one of the two necessary steps before the production of a wing is a possibility.

No one has yet attempted to consider the detail of wing specialization, or to inquire into the process or method by which it is brought about. A complete explanation requires that the

wing should be traced from the first fundaments of an outgrowth of the thoracic integument, through the modifications of form and structure essential to the performance of its function in each stage of its evolution, into a fully developed organ of flight.

The earliest insects of which we have any certain remains had well-developed wings, and wings have in all probability arisen but once among insects. All existing insects are, therefore, to be considered descendants of flying Paleozoic ancestors and to have inherited their wings through all these ages. The meagerness of all ancient geological records and the necessary absence of all direct evidence in later time make the problem one of great difficulty. The process would be almost unintelligible were it not that organs similar to those from which the wings have in all probability arisen appear to be easily acquired by insects; for this reason we have preserved to us abundant data for our investigation.

The first step in the development of wings, in accordance with this theory, is brought about as a result of a change of habitat—an insect, formerly terrestrial, becoming aquatic. If this occurred in a small insect, which was probably the case, the only adjustment necessary would be a reduction of the thickness and firmness of the cuticle. The insect was doubtless one of those living in damp situations, such as serve at the present time as the habitat of Thysanura. The situations in which these insects may be found vary from subaquatic to almost terrestrial, and the direct effect of the environment would be sufficient in the primitive insects to accomplish the differentiation of the older insects into two groups of individuals, not sharply distinct, but looking toward the specialization that later occurred: On the one hand, those that remained in the more moist localities and retained a character of skin that made possible the free absorption of oxygen from the water; and, on the other hand, those whose surroundings resulted in the older individuals quite losing this power, through the drying and hardening of their cuticle, thus confining the adult individuals to such situations as permitted the continuous breathing of free air.

The danger from disease would in time render such a neutral condition as we have imagined for the subaquatic forms quite untenable and required a modification that would harden

the skin in spite of the moisture when the insect retains, as have the existing Thysanura, the old habitat. Another modification—one, indeed, that seems to be simpler and easier of accomplishment—is the abandonment of the breathing of free air and dependence entirely on the water for the air needed. How efficient the skin is as a breathing organ in water in the case of small insects may be judged from the fact that at the present day certain small insects, such as mayflies and dragonflies in their first stages, appear to have no need of gills, being in some cases quite devoid of them.

As soon as there is an increase in size, there comes to be the necessity for a hardening of the body wall for muscle attachment, and at the same time the demand for oxygen increases much more rapidly than does the surface of the body, requiring that the breathing function be localized and perfected by the special modification of some part of the body wall. This becomes absolutely essential to the life of the insect whenever the other demands upon the integument have reduced the unmodified oxygen-absorbing area to a point where it is entirely inadequate to the demand. In the case of small insects, as for instance the young of dragonflies and mayflies, as stated above, this point has not been reached, but will be in both these insects as soon as they become larger.

Any part of the body may be specialized for this purpose either by the adaptation of an organ already existing or the development of an entirely new structure. A gill in an insect is simply any outgrowth of the body wall that retains the soft texture originally possessed by the whole body surface. When of this simple form they have been called blood gills, because the distribution of the air absorbed is dependent upon the general circulation of the blood. This organ becomes much more efficient as soon as it is invaded by a tracheal twig, for it then permits the more rapid transfer of the carbonic acid to the water outside it, and the absorption of the oxygen from the water through the thin layer of blood and the walls of the tracheal twig and the gill itself. The exchange of gases that results tends to approach a condition of equilibrium. Such tracheal gills appear to be very efficient organs of respiration.

The position of a tracheal gill probably depends upon the condition of the insect at the time that the gills are specialized.

That region which is most susceptible to the stimulation that produces growth generally—that where growth last occurred—is the region where the gills most readily form. We can conceive that the bases of the appendages and the end of the abdomen where gills most commonly occur are such regions of easy stimulation. That the region of the thoracic segment at which the wings are developed belongs to this same category we can readily believe, on account of the frequency with which another growth, the so-called margin, occurs in the corresponding parts of adjacent segments, and in these segments in very young stages.

The simplest form of tracheal gill is a tube-like process containing a simple tracheal twig. The modifications consist of the development of a brush-like bunch of such simple elements, a tree-like branching of a simple element, or a leaf-like expansion of the same; all intergradations exist between these types. There is a practical limit to the length of a gill, chiefly dependent upon the danger of injury in the case of a long organ; these modifications are the result of an effort to increase the surface without increasing the length.

Of these three forms of modifications the last is evidently the most efficient, since the whole gill surface is exposed to open water and none of it faces an adjacent surface with which it must compete for the oxygen contained in the intervening water, as is the case in the other types. There are compensating disadvantages in the increased danger of injury, as the individual portions can not give way as readily when coming in contact with objects liable to injure them. The necessity, therefore, arises of devoting a portion of the surface to strengthening ribs or veins, and a greater or less thickening of the whole upper surface, making it somewhat more resistant and, therefore, less useful as a gill. The production of the wing from a gill of this sort would result in the early loss of its utility as a gill, so we can not look upon it as the precursor of the wing, even though there may be a striking similarity in general appearance.

Another specialization, one that affords a better transition toward a wing, is seen in those insects in which a portion of the gill is devoted to the function of protecting the remaining parts, permitting them to retain their most efficient gill structure even under rather adverse conditions. Just such an organ

may be seen in the gill cover of a species of mayfly common in Illinois, *Rithogena manifesta* Eaton (*Baetis debilis* Walsh); as shown in Fig. 1. This is not the most wing-like gill found in the family, but will show as well as any the tendency of its specialization toward the structure of a wing.

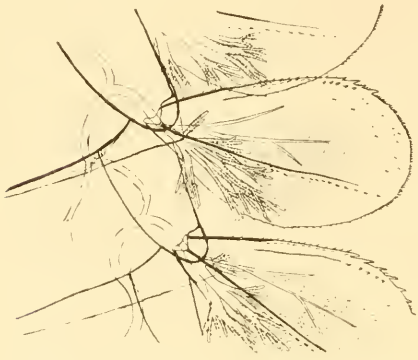

FIG. 1. A portion of the abdomen of a mayfly nymph (*Rithogena manifesta* Eaton), showing tracheal gills and gill covers.

The shape, while not exactly like any existing wing, still in its general outline suggests very closely the form of wing which several authors have considered the primitive shape.

The ornamentation of the edge by spines and hairs is so exceedingly wing-like that it might almost be duplicated in detail by the wings of some of the lower Diptera.

The surface of this gill cover, while not entirely free from the function of respiration, still has most of its area modified, and in the apical region possesses an arrangement of surface hairs not essentially different from that found on the wings in many groups of insects.

The most convincing evidence of the relation of such an organ as this gill cover with wings is to be seen in the vein-like stiffening of the membrane. These structures possess all the characteristics of veins. They have, moreover, a definite relation with rows of special spines, such as so often occur with veins. The only matter characteristically different is the want of any relation between these veins and the tracheæ of the gill covers. The gill covers are quite well supplied with tracheæ, but they do not in any instance correspond with the vein-like structures in these organs. It is possible that we have here a stage in the development of the wing preceding that in which the tracheæ become coördinated with the veins.

Still another matter making these gill covers comparable with wings is the nature of the articulation. The alar articulation must have been produced from a structure of this sort.

A great many insects living in water have a very curious

habit of vibrating the body, apparently to assist in respiration by causing the water bathing the gills to mix with the surrounding water and so become purer and fresher. When an insect possesses gill covers, the same change may be effected by the vibration of these. Any process attached to the body as the gill covers are, would be caused to vibrate with every movement of the segmental muscles and particularly by the contraction of the dorso-ventrals. The gill cover that we have been considering moves quite freely. The economy of this means of keeping up the circulation of water is at once evident. The musculature and the first steps toward the specialization of the thorax for flight are thus provided for.

A difficulty that has presented itself to the minds of many students of the subject of imaginal characters is that of accounting for the repression of an organ during larval life, or the holding of its development in abeyance until the final molt. The precursor of the wing, according to any theory connecting it with the tracheal gill, must have been functional in the larval insect. Wings would, therefore, seem to offer one of the most difficult of these problems; that is, the entire suppression of all the earlier stages.

A closer study of this subject shows that this is only an apparent difficulty, for there is no real suppression in the larval stages in the case of the wings, since they often, and perhaps generally, appear quite as early as the true gills, and represent at first nearly the condition of gill covers. The change into wings (that is, its development beyond the gill-cover stage) is all that belongs to the penultimate stage.

Another kind of suppression has really occurred in the case of insect wings, whereby the organs have become limited to the thorax. Much of the difficulty in this case disappears, however, when we note that the same problem has been met in the case of gills that retain their original function. I refer to the remarkable case of insects of the genus *Cænis*, where one pair of gill covers has become very like an elytron, is almost or quite gill-less, and protects the naked gills of the following four segments. On the other segments of the abdomen the gills have entirely disappeared. An exactly similar process, but one resulting in two pairs of gill-less covers and an entire suppression of all gills in the last molt, would give us the condition of the winged insect.

Résumé.—Thus we see that the wings are hypodermal specializations of the meso- and metathorax, essentially similar in all insects, and, according to the most probable theory of origin, are of indirect development. The theory of Gegenbaur that the wings came from tracheal gills, when compared with that of Müller, either in its original form or as modified by Pancritius or Packard, is seen to be much nearer the facts, but must be modified along lines similar to those suggested by Lang. With this modified theory it is possible to trace the evolution of a portion of the gill till there is produced an organ approaching so closely to the structure of a wing that the transition would not seem to present any very serious difficulties.

RELATION TO THE BODY.

There is a considerable difference of opinion as to the place on the segment occupied by the wing. This is in part due to apparent differences observable in the place and manner of origin in different insects. In most of the lower insects the wingpads appear to be processes of the notum of the meso- and metathorax, showing first at the extreme posterior angle as a slight elongation. In later molts they extend till they commonly involve nearly or quite the whole length of the respective segments and inwardly along the hind edge sometimes a third of their width. They appear, as just stated, to belong to the notum, being usually in the same general plane of the disk of the notum and so little different from the normal structure that it is not possible, at least at first, to distinguish a dividing line, while on the other hand the angle they make with the side pieces sharply separates the wingpads and the pleuræ almost from the first.

Exceptions to this statement are found (*a*) in the saltatorial Orthoptera, where the wingpads, as described by Riley ('76) and Graber ('77), arise in the ordinary manner, apparently from the notum, and suddenly at one of the molts reverse their position and project upward instead of downward, thus coming to be apparently processes of the pleura, but always with a distinct line of demarkation separating them; (*b*) in the Embiidæ, where, as pointed out by Wood-Mason ('83), the wings have no connection with the posterior part of the segments to which they are attached, but come from the extreme anterior portion; and (*c*) in the Odonata, where the wingpads

from the beginning project dorsally, and thus appear to be outgrowths of the pleuræ. Comstock and Needham ('98–99) remark that "they appear at a time when the tergum and pleura are very little chitinized and are hardly more identified with one than with the other." The wingpads in Odonata also differ from those of most of the lower insects in that they arise from the middle of the segments and only later extend forward and backward across their whole width.

Among the higher insects the wings seem uniformly to arise from the middle of their respective segments somewhat dorsal of the legs, but at a time when there is no evident differentiation of dorsum and pleura. They usually appear well

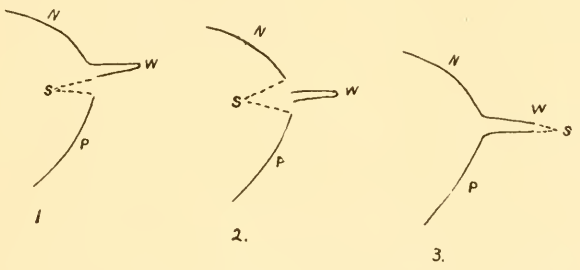

FIG. 2. Diagram illustrating the relation of the wing to the dorso-pleural suture.

1. The commonly received view.
2. Comstock and Needham's view.
3. Calvert's view.

n, notum; *p*, pleura; *w*, wing; *s*, suture.

up toward the back and lie in such a position that the tip is directed downward and posteriorly, giving one quite the same impression as do most of the wingpads in the lower insects, viz., that they are processes of the dorsum. Packard ('98) goes still further in the case of the Hymenoptera by regarding the wing fundaments as scutal structures. No one else has attempted to locate them so closely, but their derivation from the notum has been the conception of nearly all those who have expressed any opinion in the matter. Two very recent authors, however, have given expression to other and entirely distinct views.

Calvert ('93) says, while discussing the Odonata, that the upper lamina is "tergal and the lower pleural," and presumably maintains the same for other insects. No evidence is cited in favor of this view. Comstock and Needham ('98–99) incidentally give expression to another idea by describing the

rudimentary wings as arising "at the point where the suture between the tergum and pleura later develops." Stated in other words, these three views are as follows: According to Calvert's view both articular membranes are independent of the dorso-pleural suture; according to the common conception the lower articular membrane is formed at this suture; while the idea expressed by Comstock and Needham woud seem to make the suture the source of both articular membranes.

There is the possibility that these differences in theory and the apparent differences in fact are the result of actual differences in origin; that is, wings may not be in all cases strictly homologous structures. But the degree of uniformity, or rather the lack of distinctive characteristics for the separation of wings into groups, indicates very strongly that we have to do with a single monogenetic organ and the differences must be considered secondary.

Morphological evidence, as far as I have been able to accumulate it, has failed to yield any very decisive conclusions in regard to this problem, but does concur with the results arrived at from somewhat theoretical considerations regarding the part played by the wing in the evolution of the thoracic segment. The structure of insects has been quite elaborately investigated from some standpoints, but the order and method of specialization of the parts of the thorax have quite escaped the consideration of investigators.

I will only briefly outline what appear to be the salient points in the process and those that have a bearing on the problem in hand. The accepted nomenclature, that of Audouin ('24), who made the first comprehensive study of the structure of the thorax, is based on the idea that a segment consists of a number of separate pieces, called sclerites, grown together into a more or less solid ring. Audouin recognized one sclerite belonging to the ventral region, the sternum; two belonging to each side, the episternum and epimeron; and four dorsal pieces arranged in a series from before backward, the præscutum, scutum, scutellum, and postscutellum. Besides these were the legs and wings and their accessory basal pieces. The tergal pieces, like the pleural, are separated from each other by transverse lines at right angles to the axis of the body and to the lines that divide the tergal pieces from the pleural, and these latter from the sternum.

The theory has been suggested by Hagen ('82) and others, but I believe in most cases only tentatively, that a thoracic segment, like the head, is a composite region of the body, and owes its complexity, in part at least, to its possessing traces of the primitive segments. The wing in this case might even be considered a modified leg, as it is in birds. It need scarcely be said that, in this form at least, the theory is certainly untenable. Very recently the idea of a double origin of the thoracic segment has been seriously revived in a somewhat new form by Walton ('00). As the result of a study of the basal portion of the leg, he conceives that the peculiar structures found there are the result of the fusion of two successive legs, the posterior one being rudimentary, but contributing a large portion of the basal segment. The two pleural pieces, according to this view, would represent the sides of the two primitive segments. Walton does not discuss the bearing of this theory on the problems of the wing and of the notal structures. His idea in the matter, however, seems to be that the wing belongs to the second primitive segment, and the corresponding organ in the anterior segment is represented in the mesothorax by the patagia in Lepidoptera and the tegula in Hymenoptera. The dorsal division between the two primitive segments would evidently be that between scutum and scutellum. All the facts that have been cited in favor of this theory can be explained fully as satisfactorily without supposing the segment to have a double origin. The greater part of what follows regarding the specialization of the thoracic somite would not be seriously affected even if the double origin were demonstrable. We shall assume, however, that each segment of the thorax is developed from a single articular somite.

The key to the solution of the problem of the specialization of the thoracic segment appears to be its skeletal function. The skin of the insect is the sole place of attachment of the muscles of the organs of locomotion. The thorax is specialized for this function and correspondingly relieved of other duties. The head contains the mouth and most of the sense organs, and the abdomen, at least in the adult insect, performs most of the vegetative and reproductive functions, and neither of these regions shows skin structures that can be definitely identified with the parts of the thoracic segment, except in a most general way. Thus, the peculiarities of the thorax both in

structure and function, and the very evident dependence of the function upon the region specialized, lend considerable presumptive evidence in favor of the idea here advanced, that the specialization is in fact dependent on the function.

There are many facts bearing on this problem, to which it will not be necessary to refer in detail, by means of which the course of the development of the segment may be traced from the simplest type of structure, such as occurs in the lowest articulata, or in the apodous larvæ of insects, or only slightly more complex in the abdomen of many adult forms to the most complicated. There are evidently two stages in the development of the thoracic segment: first, the one embracing those changes that follow and are dependent on the development of the leg; and, secondly, the one embracing those which are quite as evidently to be assigned to the specialization of the thorax for flight.

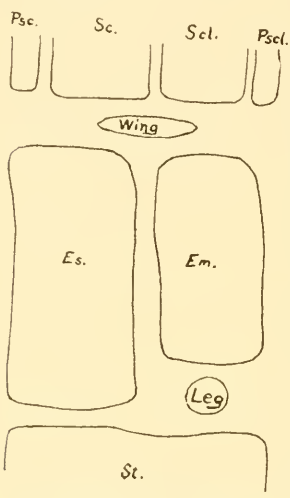

FIG. 3. The thoracic segment according to Audouin.

st, sternum; *em*, epimeron; *es*, episternum; *psc*, præscutum; *sc*, scutum; *scl*, scutellum; *pscl*, postscutellum.

Before discussing the nature of these modifications it will be useful to note the nature of the suture separating the thoracic sclerites. Contrary to the usual conception, these sclerites are not to be considered as separate pieces in the same sense that the segments themselves are separate. The division of the segments is brought about by a specialization of the cells of the connecting membrane, whereby they do not take part in the modification that occurs in the other cells of the skin resulting in a harder and thicker cuticle, but become instead capable of producing thinner and more flexible cuticle. The purpose of this thinning is to afford a freer motion between the harder parts. Another example of the same kind of specialization is found in the separation of the dorsal from the ventral portion of the abdominal segment, and it is developed for a similar purpose, that is, for motion. There is considerable modification for motion, and therefore of the segmental type, at the base of both the legs and the wings, but it should be clearly understood that the sutures between the thoracic

sclerites have a different nature and have arisen to meet different needs. The latter consist of linear invagination, which are characterized by harder rather than softer cuticle and result in the stiffening of the region in which they are developed.

The first and most important result of the development and perfection of the legs is the production of the sterno-pleural suture. The space occupied by the basal joint of the leg greatly weakens the segment at a critical point, but it is entirely compensated for by the production of this suture and the stiffening of the edges of the pedal foramen. This region, instead of being weakest, thus becomes in fact the strongest and stiffest part of the segment.

A second change following the development of the leg is the stiffening of the parts of the segment that bear the strain of the muscles of the legs. There is some variation in the arrangement and working of the muscles at the base of the legs of insects, but we shall consider only the more common, and undoubtedly primitive, arrangement, which consists of three principal muscles: one extending toward the venter and two toward the sides, one of which is anterior and the other posterior. The ventral muscle was necessarily short at first and attached at an unsatisfactory angle, but gradually became accommodated by an ingrowing process from the back of the middle line of the venter, and the difficulty was thus wholly overcome. This process, which is of various shapes and sizes, forms part of the so-called internal skeleton; though of much physiological importance, it affects only very slightly the external appearance. The side muscles did not require such elaborate changes for their attachment, but did require a stiffening of the body wall of the side, which was more conspicuous externally. This was accomplished in the simplest and most effective manner by the stiffening of the edges and of a line down the middle of the side between the muscles, thus furnishing on each side of each muscle the stiff support needed. The sutures thus formed, showing as ridges internally, conspicuously divide the side into the two regions, the episternum and the epimeron, which are distinct below, but not delimited above, where they extend feebly over the back from side to side. This is the condition of highest development reached until structures evidently associated with flight or with some other special requirement arise.

The final steps in the perfection of the thoracic segment are not very dissimilar to those just described. The most striking part of this specialization is the separation of the notum from the pleuræ to make way for the attachments of the wing, which results in the completion of the specialization of the pleuræ. The thickening which forms the interpleural suture is still further strengthened to serve at its upper end for the articulation of the wing, and the upper edges of these sclerites are not only cut off sharply from the parts above, but are also thickened. This is required by the fact that the shape of the base of the wing is such that the segment is nearly cut in two for its attachment. The notum keeps its connection with the pleuræ solely by the narrow strips at either end.

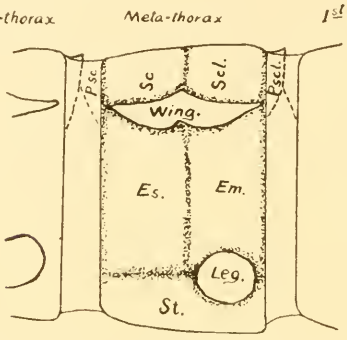

FIG. 4. Diagram illustrating the new theory of thoracic specialization.

st, sternum; *em*, epimeron; *es*, episternum; *psc*, præscutum; *sc*, scutum; *scl*, scutellum; *pscl*, postscutellum. Stippled portions indicate thickenings; dotted lines, encroachment of dorsum on the intersegmental membrane. For clearness, segments are imagined pulled apart to an impossible extent.

There is a very striking contrast in the kind of modifications of the thoracic segments necessary to adapt them to the musculature of the wings, as contrasted with that for the muscles of the legs.

With the exception of the Odonata and Ephemerida, insects have a large longitudinal dorsal muscle, the contraction of which causes an arching up of the notum; since the latter is attached to the inner end of the wing root, its arching produces the downward stroke of the wing. To provide for the attachment of this muscle, the front edges of the meso- and the metathorax and of the first abdominal segment are developed as deep infoldings, almost making diaphragms across the body when highly developed. These infoldings are produced by the chitinization of the connecting membrane as it grows inwardly, and forms two additional pieces, as seen from the outside, uniting closely in most cases the backs of the adjacent segments. The accompanying diagram (Fig. 4) gives the appearance of a segment according to this theory.

In the Odonata and Ephemeridæ there is no deep infolding for muscle attachment, but the external appearance is not very different, the additional pieces evidently resulting from the need of a firmer attachment for the parts that vibrate with the wings and in the perfection of the anterior and posterior notal articulation. The præscutum of the mesothorax and the back of the first abdominal segment are especially developed to strengthen the thorax, because the remainder of the mesonotum and the whole of the metanotum are loose and beat with the wing.

As a *résumé*, we may recall that the position of the wing on the segment, though subject to some variation, always marks the division between dorsum and pleuron, but there is difference of opinion as to the exact relation of these parts. The theories of composite segments in the thorax seem to be entirely untenable and would not throw light on the question, if true. The real solution requires a study of the specialization of the thoracic segment, and must include the consideration of thoracic functions. Two distinct types of sclerite division may be distinguished, one for articulation, the other for resistance; both of these occur in the thorax, but the latter only causes the separation of the principal sclerites. The first stage in thoracic specialization follows the development of the legs, and results in the separation of the sternum from the remainder of the segment and the beginning of the division which ultimately separates the episternum from the epimeron and the scutum from the scutellum. The completion of this division, the separation of the dorsal from the pleural region, and the development of the præscutum and of the postscutellum, mark the final stage, which is brought about by the development of the wings, and the wings can not, therefore, be considered as a product of either the pleuron or the notum, but rather as the means of their differentiation phylogenetically as well as ontogenetically.

FLIGHT.

The one fact in regard to which all authors who have written on the subject of flight in insects are in agreement, is, that insect flight is not comparable with the flight of birds. The path over which the wing of an insect moves in flight is shaped like the figure 8, contrasting sharply with the oval path of a bird's wing. Furthermore, it is to be noted that while the

bird's wing is different on the two sides, that of an insect presents the same kind of surface to the air in both phases of the stroke, and finally, as pointed out by Amans ('85), the structure of the flying apparatus as a whole, as well as in every detail of structure, is fundamentally different in the two groups.

The path of the wing in flight is evidently correlated with the nature of the articulation at the base of the wing, but whether the articular structure requires the wing to pass through the air in the course indicated, or is simply flexible enough to permit the air resistance to force the wing out of what would otherwise be a simple to-and-fro motion, is still a subject of controversy. This latter theory was first propounded by Marey ('69), and was the result of very careful observation and experiment. The opponents of this view include two of the three who have made a serious study of the articulation of the wing. The third, Amans ('85), does not take sides with either party, but expresses himself as incompetent with only anatomical data to decide the matter.

The observations of both von Lendenfeldt ('81) and Lowne ('90–95) were confined to single insects with rather complex structure, and in the case of von Lendenfeldt not with the one that was studied for hinge structure. While both of these authors agree that the course of the wing is determined directly and entirely by the muscles of flight and the articular structures at the base of the wing, they differ in a matter of fact of fundamental importance. The point at issue is the direction taken by the wing in passing over its characteristic path; whether, for instance, the wing when passing over the part of its course farthest above the body as seen from the side is moving forward, as described by von Lendenfeldt, or backward, in conformity with the views of Lowne and Marey. The method employed by von Lendenfeldt, that of photography, gives with perfect accuracy a series of positions which, by attention to the effects of air pressure on the different parts of the wing, should give unmistakable evidence as to the direction in which the wing is moving. We have no means, however, of determining, from the figures given, the correctness of his interpretation of the photographs. In like manner, Marey's results, though doubtless clear to him, can not be correctly interpreted by any one else, because he mentions neither the direction of the movement of the cylinder nor the position of

the head of the insect when making the record. If the insect were heading toward the direction from which the cylinder turns, which would be the natural thing to do, then Marey's records substantiate his theory. There is the possibility in all this work that the insect may reverse the action of the wings—which in some cases at least it seems to have the ability to do—and thus make false records, though this is not likely to happen often, for reverse motion is apparently always of short duration. Lowne's work is based almost entirely on the action of the wing in a dead insect, and is open to the criticism that there is no good evidence that the action studied is that which actually occurs during flight.

The accompanying figures (Fig. 5), based on the curves elaborated by von Lendenfeldt, illustrate the motion of the wing of *Agrion* in flight. As seen from above, the path appears to be practically the same, whichever course the wing follows; from the side, however, the route of the stigma is essentially different, as is shown in the diagrams.

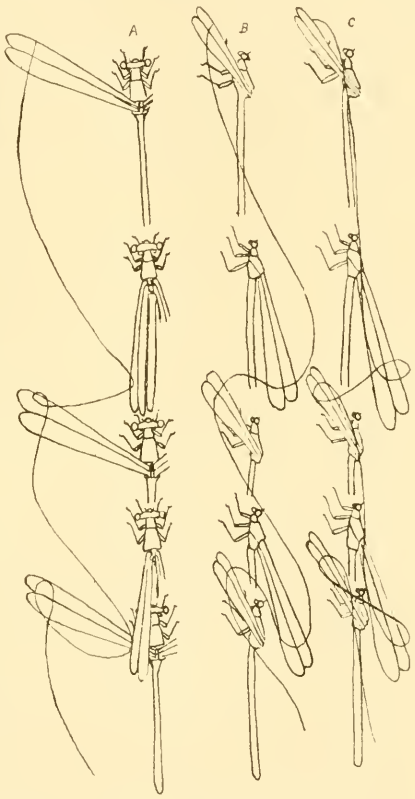

FIG. 5. Diagram illustrating the flight of *Agrion*.

A. From above, the curved line showing the path of the stigma. B. From the side, according to theory of von Lendenfeldt. C. From the side, according to theory of Marey.

This insect, as well as the blowfly, the species studied by Lowne, moves its wings much more nearly in a direction parallel to the axis of the body than dorso-ventrally, but the latter was doubtless the more primitive motion. The common white butterfly, *Pontia rapæ*, moves it wings in a nearly direct dorso-ventral path. In such an insect the mechanics of flight

may be illustrated by the diagramatic projection shown in Fig. 6. In an insect viewed from the left side let AB represent the hinge, or axis, about which the wing swings at each stroke, the direction of progression being from B toward A. Let the line CD represent the mean inclination of all parts of the wing during the up stroke, and C′D′ the same during the down stroke. These lines CD and C′D′ converge behind, because, as is well known, the more flexible posterior field of the wing yields more to the resistance of the air than the anterior margin and, therefore, lags behind in both upward and downward strokes. Draw from any point O of the line AB, perpendiculars OE and OE′ to the lines CD and C′D′; then the lines OE and OE′ represent the direction of the force exerted by the wing during the up and down strokes respectively. Perpendiculars to the line AB from E and E′ (FE and FE′) represent the amount of this force which is neutralized by reason of the opposition in direction of the two strokes, and 2OF the net resultant force producing forward propulsion.

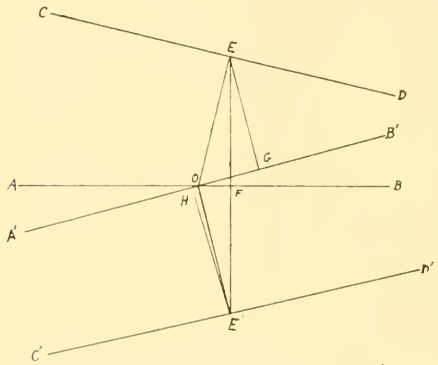

FIG. 6. Diagram illustrating mechanics of flight.

AOB, horizontal line; A′OB′, axis of body; CD and C′D′, mean inclination of wings; EFE′, perpendicular to AB; EG and E′H, perpendiculars to A′B′.

A more economical motion would be produced by increasing the obliquity of the lines CD and C′D′ to the base line, AB; but it would require at the same time a greater rapidity of stroke to maintain the same rate of progression.

Such motion as that just described requires, in order to accomplish horizontal flight, that the axis of vibration lie somewhat obliquely to overcome the effect of gravity. In the diagram let A′B′ represent the actual line of motion. Now, drawing the lines EG and E′H perpendicular to A′B′, we have the lifting power that opposes gravity represented by E′H minus EG, and the propelling force OG minus OH. At both the beginning and end of the stroke the two pairs of wings oppose each other, and thus exert no lifting or depressing

action, so that the ratio shown in the diagram between the vertical and horizontal forces is entirely out of proportion, the former being much exaggerated.

Besides the to-and-fro motion just discussed, there is also a motion along the plane of the wing resulting in the figure 8 path already referred to. The width of the loops varies greatly in different insects, and in the same insect the exact course is dependent in part on the speed, but more on the character of the stroke, which the insect seems to have the power of varying more or less. This power is seen very strikingly in those insects that poise themselves in the air, as do most of the bees and such flies as Bombilidæ and many of the hawkmoths.

Now, Marey has shown that a body constructed like an insect wing moving to and fro will be forced from its direct course and caused by the resistance of the air to travel over just such a path as an insect's wing is known to follow. The front part of the wing being the more rigid, the effect of the air resistance will be such that the whole wing will become twisted near its base, and if the wing attachment permit, this resistance acting obliquely on the wing disk will also force the tip of the wing forward during each stroke. At the end of the stroke the elasticity of the articulation and of the wing membrane will bring the wing back to its normal position. This occurring at each stroke, both up and down, the result will be the characteristic curve. In such an insect as the butterfly, air pressure, acting as here described, appears to be sufficient to account for the curve of motion. Marey, indeed, believes the air pressure alone is sufficient to explain the curved path in the case of all insects.

There is, however, the possibility that air pressure will produce just the opposite effect from that described above, provided the hinge at the base is sufficiently rigid to prevent the forward motion of the tip of the wing, and provided the membrane is sufficiently lax to bag and take on the helix shape. This is the condition which has been insisted on by Pettigrew ('71), and is illustrated in the beetles. The result of the "bagging," in this case, is the pulling backward of the tip of the wing and its release at the end of each stroke, allowing the wing to straighten out and the tip to move forward by its own elasticity. The curve thus produced would resemble that previously

described, but its direction would be reversed. Undoubtedly this tendency to bagging is a factor in the flight of all insects, unless the wing is so stiff as not to bend appreciably during a stroke; but in a beetle it becomes of high importance, if not, indeed, the controlling factor. As far as I know, the question of the direction in which the wing moves during the flight of a beetle has not been investigated.

A second force which modifies the stroke of the wing is the action of the wing muscles directly attached to the base of the wing, of which quite a number have been described. By means of these muscles the wing can be pulled forward and backward; moreover, the angle which its plane makes with the frontal plane of the body can be varied. These muscles are evidently the means by which the insect varies the precise nature of the stroke of the wing, and also doubtless in most insects they are the means of placing the wing into most of the positions of rest assumed by this organ in different insects and of bringing it again into position for action.

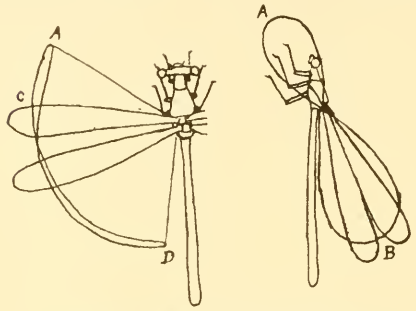

FIG. 7. *Agrion*, showing figure 8 path of wing as seen from above and from the side.

A, position of wing when ready to fly. B, position of complete rest. C, position of rest with expanded wings.

If the action of any one of these muscles should become synchronized with either set of the muscles producing the wing strokes, it would doubtless greatly modify the path of the wing. The muscles which Amans denominates the preaxillaries or anteaxillaries pull the wing forward; the postaxillaries pull it backward. With such a curve as occurs in *Pieris* a preaxillary or an anteaxillary would augment the width of a curve, and a postaxillary diminish or reverse it.

Supposing that such a synchronization occurred, it is probable that in most cases there would not be an equal association of axillary muscles with both systems of primary muscles, so that the probable effect would be the exaggeration in the size of one loop of the curve. An exaggeration of this kind, though I can not state if for this cause, is exhibited by the posterior loop in a side view of the curve in *Agrion* (Fig. 7).

This same unsymmetrical path could result from air pressure, if the angle of the wing were different in the two strokes, as might be produced by peculiarities of the hinge structure, in which different bearing joints are brought into operation in the two strokes, the wing lying free between them when at rest. Another way in which the character of the curve might be influenced by the hinge structure is by the development of a catch which should restrain the wing at one or both ends of its course while the wing is traveling in one direction, and not affect it on the return stroke. The sudden release of the wing from this catch would result in an immediate change in the

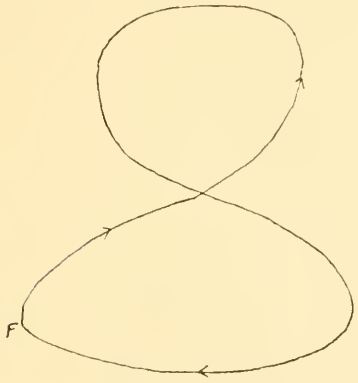

FIG. 8. Diagram of the stroke of the wing in the blowfly, according to Lowne. F, point at which there is a sudden change of direction.

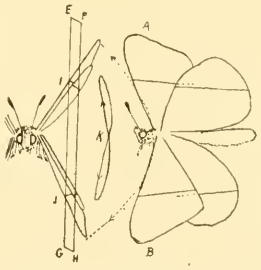

FIG. 9. Diagram illustrating flight of *Pontia rapæ*. A and B, two positions of wing. EFGH, a plane intersecting the wings at I and J. K, path of motion.

direction of motion. In this way there would be produced just such an angle as is given by Lowne at point F (see Fig. 8) in the path of the tip of the wing in a blowfly, at which place, according to his account, "the hammulus escapes from the uncinate sclerite." This would produce an unsymmetrical curve, unless an exactly similar structure were developed at the opposite point. This is probably never accomplished, and an influence of this kind on wing motion is of only secondary importance, if indeed it ever occurs.

The three methods of modifying the stroke described above may all be considered as possibly operating in particular cases, but only one factor—air pressure—is invariably present. A wing with a simple up and down stroke modified only by the influence of air pressure may be considered as representing

the simplest and most primitive condition, and is to be seen in a butterfly like *Pontia*. Fig. 9 indicates the nature of the wing motion under these conditions. The angles at which the wings cut the plane EFGH indicate the oblique position given the wing by the air pressure, and explain its efficiency for forward propulsion during both phases of the vibration.

If one watches the flight of this insect when, during its passage, it is directly opposite him (Fig. 10), or when it is coming directly toward him, he will notice that the body moves up as the wing moves down, and vice versa. A still more striking example of this bobbing motion may be seen in many Lycænidæ. In the larger Papilionidæ and in the higher Nymphalidæ the motion is commonly more steady, and in the

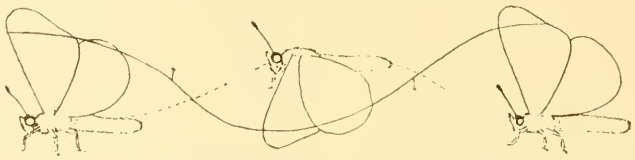

FIG. 10. Flight of *Pontia rapæ*, showing up and down motion of body.

Hesperidæ, where the wings move very rapidly, the body vibration is difficult to distinguish at all, but is presumably present. A stroke of this kind is not as efficient as one in which the wing moves more nearly in the plane of body motion, because of the loss of power in the process of lifting the body up and pushing it down again, which must occur with an up and down stroke.

From this type of stroke to that exhibited by a fly or bee, or that of a damsel-fly shown in Fig. 5, there are all stages of transition. These may be found in a single family, the hawkmoths. While the stroke of this type is more efficient it is of necessity more rapid, for the wings cease to act as aëroplanes and become paddles. A single stroke of a broad wing may carry an insect many times its own length, whereas, if the stroke is nearly directly backward, the insect can not make much more than its own length, even counting the movement due to momentum, which acts, during the recoil of the wing, in keeping up the progress. The backward stroke is the most efficient propelling force in this type, and while this is being made the tip of the wing must, to be effective, move backward considerably faster than the body moves forward. The forward stroke

aids the flight chiefly by lifting the body, and to a large extent the wing simply feathers forward.

The oblique or direct stroke is accomplished by shifting the dorsal articulation of the wing backward, or the ventral bearing-point forward, or, in the case of the damsel-flies, by the movement of the whole dorsal region of the meso- and metathorax into a position almost at right angles to that originally held. The stroke is from above and behind forward and downward, or vice versa.

In the majority of insects, especially in those in which change to an oblique direction has not been carried to an extreme, the course of the wing is probably that described by Marey. Unfortunately, I can not speak with certainty in regard to either of the insects (Odonata, blowfly) in which the contrary motion has been claimed. In regard to them it may be said that they are both evidently very highly specialized; both possess the habit of assuming a peculiar position, not one of rest, just before beginning to fly. The damsel-fly shows this particularly well. In the blowfly it is not as evident as in some of the other Dipterous families, such as Syrphidæ, Conopidæ, and many others. It is not impossible, therefore, that these insects may pass over the course that they have been described as following, though it involves a remarkable change in the nature of the wing motion as compared with that of other insects.

The presence of air sacs in great abundance in the bodies of all flying insects has often been discussed, and they have often been compared to the swimming bladder in fishes, the explanation offered being that they enable the insect to change its specific gravity. The uselessness of such a contrivance to aid in flight is so evident that it is strange that text-books have so long copied the suggestion. The only other explanation of this function that has been offered is that of Packard, who suggests that they are a means by which a larger supply of oxygen is provided for the muscles during their very violent action in flight. This does not appear to be a sufficient explanation, even though the air sacs may aid respiration materially in the manner suggested. It is especially the distribution of the air sacs that counts against the idea that this is the sole cause of their existence.

A possible use of the air sacs that may explain their arrange-

ment in some cases is that they may aid in adjusting the center of gravity; the inflation of air sacs in one region causing the body fluids to occupy another. This reason, however, can not account for their distribution.

What appears to be the most important function of the air sacs is their utility in the recoil after the wing stroke. The muscles of flight are all so attached that the body contents at the end of each stroke are greatly compressed and the return stroke is started as a recoil from this tense condition. The elasticity of the body wall of the thorax produces this result without the aid of the body contents, but not as well as with it. If the body cavity is tense, as by the inflation of the air sacs, the recoil becomes to a large extent pneumatic.

Résumé.—We have thus seen that the flight of insects is a process not duplicated elsewhere in the animal series; it is unique not only in the matter of the structure of the wings and other flying mechanism, but likewise in the character of the stroke. There is still need of investigations that shall settle the question of the exact nature of the stroke in the higher forms. The mechanics of flight in its simplest form is not very complicated, but in more specialized types of wing structure several factors contribute toward its complication. Of the factors modifying the stroke the effect of the resistance of the air against the surface of the wing is always in evidence, causing the wing to take an oblique position during each stroke. The stroke may be further influenced by the action of the minor muscles at the wing-roots, either temporarily or continuously by their synchronization with the primary muscles. Peculiarities in the structure of the articulation may also contribute to the modification of the stroke in many ways. The slower, vertical stroke contrasts strongly with the more steady and rapid oblique movement of the wings, and the latter presents a number of details requiring further investigation. Finally, a possible relation of the air sacs with the recoil at the beginning of the stroke is pointed out as the most reasonable explanation of the development of these structures.

ARTICULATION.

The articulation of the wings of insects has been carefully studied by only three investigators: von Lendenfeldt ('81), who described with great detail the structure in one of the

dragonflies; Amans ('85), who gives us the only comparative study of the subject and covers all the principal groups; and Lowne ('90–95), who, confining himself to a single insect, the blowfly, makes a notable contribution by his very complete and painstaking account of the structure.

The investigation of Amans is the most nearly in line with the question of articulation now under consideration. As a result of his investigation he reached the conclusion that all the parts of the entire articular mechanism are comparable,

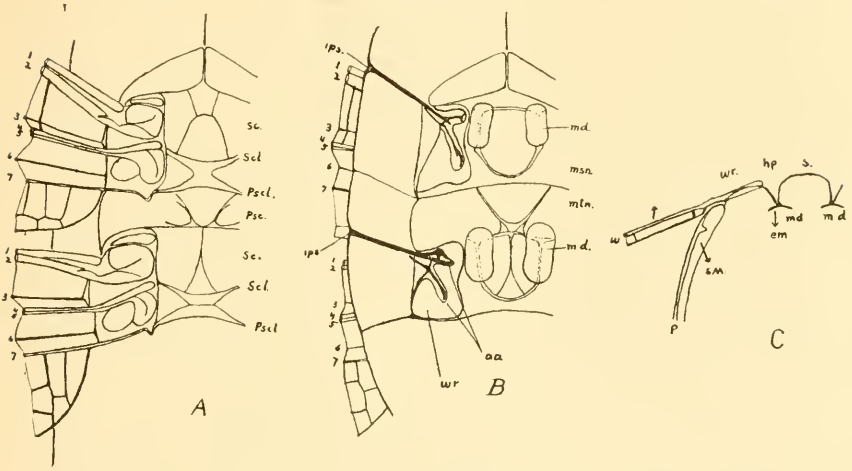

FIG. 11. Wing articulation in *Æschna* A, from above; B, from within; C, in section.

s, *sc*, scutum; *scl*, scutellum; *pscl*, postscutellum; *psc*, præscutum; *ips*, interpleural suture; *md*, muscle disks; *msn*, mesonotum; *mtn*, metanotum; *w*, wing; *wr*, wing-roots; *aa*, articular apophyses; *sm*, depressor muscle; *em*, elevator muscle; *hp*, hinge piece; *p*, pleuræ. 1–7 veins.

piece by piece, throughout the whole series of insects; he includes in this category of homologous structures not only the hinge proper, but also all the veins that reach the base of the wing.

Upon this point there is room for a decided difference of opinion, there being abundant reason for the view, first suggested by Chabrier ('20–22) and adopted by Pettigrew ('71) and Jousset de Bellesme ('79), that the Odonata present a different type of structure from that found in the higher insects.

A reëxamination of the structure of *Æschna*, the insect studied by both von Lendenfeldt and Amans, is highly desirable. Both of these authors recognize five veins as reaching

the base of the wing, von Lendenfeldt's sixth ending, as it does, on the fifth some distance from the wing-roots. There are really seven veins (compare Fig. 11), as the first and fifth, on account of their close proximity to the second and fourth, were overlooked by both observers. This, however, does not materially affect the questions regarding the articulation of the wing.

The bases of the fore and hind wings are easily and strictly comparable, so that the following description will apply to either (see Fig. 11):

The first vein, which has rarely been distinguished from the second, lies immediately on the front margin of the wing. Except at the base of the wing, the first is distinctly ventrad to the second, lying in close proximity to it throughout the whole length and continuing as the marginal vein around the outer and posterior edge of the wing.

The second vein forms at the base the anterior wing-root. Before expanding into the root it is first narrowed obliquely and then broadly constricted. The wing-root consists of a black plate immediately attached to the vein, in front of that a broader, green-colored expansion, and finally in front of this a detached, somewhat clavate, dark-colored portion.

The third vein is very far ventrad of the adjacent ones. Its outer extremity is at the nodus, and its basal termination is a simple rounded enlargement free from any attachment. Just distal to the basal end, this vein is bound to the adjacent veins by a triangular cross vein, the three veins being attached to the angles of the triangle. The anterior ventral limb of this triangular cross vein is somewhat enlarged and bounds externally the anterior condyloid cavity of the wing-root.

The fourth vein is the strongest one in the wing. At the base it is somewhat flattened and expanded vertically, forming the front edge of the posterior wing-root.

The fifth vein is usually confused with the fourth, to which it lies closely appressed. Distally it ends in the arculus. At the basal end it expands into a large L-shaped portion constituting the bulk of the posterior wing-root. Between the limbs of the L projects the green tuberosity of this root.

The sixth vein is deeply ventrad to the adjacent veins, nearly as much so as the third. The basal end is abrupt and slightly expanded, apparently for muscle attachment. It is

connected by a feeble cross vein with the fifth, and by a stronger enlarged one with the seventh. This appears to bear the same relation to the posterior condyloid cavity that the vein between the second and third does to the anterior. There may be some connection between the base of this sixth vein and the green tuberosity, or with the black corrugations beneath it, but this is certainly not very evident.

The seventh vein ends at the base in a tracheoid structure that bends ventrad near the posterior end of the L-shaped portion of the posterior wing-root, and then proceeds dorsad and across the body to meet the corresponding structure from the opposite wing, forming the posterior boundary of the X-shaped portion of the notum.

The parts of the body that come in contact with the wings are a little more difficult to compare in the two segments, but in most features associated with the wings there will be no difficulty in recognizing the homologies.

The closest attachment between the body and wing is where the tissue about the suture between the side pieces is extended upward into a process, which is reinforced by a triangular sclerite bearing articular apophyses (Fig. 11, *aa*). These sclerites are evidently chitinizations of the articular membrane above the two pleurites. Their processes are strengthened by a system of rod-like, cuticular thickenings, as shown in Fig. 11, B. The lower lamina of the wing is continuous, as a soft flexible membrane, with the ends of these pleural processes.

Dorsally the posterior wing-root (Fig. 12) is opposite the X-shaped portion of the notum, which is evidently composed of the scutellum and postscutellum, the hard parts of which meet only at the middle and diverge laterally with a rather delicate membrane between. The postscutellum is for the most part tubular; and it is tracheate and directly continuous, as already described, with the end of the seventh vein. The ends of the scutellum project rather deeply into the body and approach closely to the deeper portion of the end of the hinge piece lying between the anterior wing-root and the scutum. As seen from within (Fig. 11, B) the end of the scutellum is found to be continuous with the longitudinal support of the muscle disk to which the elevator muscle is attached. The scutum has a broad, rather smooth surface, which in the vicinity of the wing dips deeply into the body and there expands into muscle disk.

The action of the mechanism of the wing, as shown in Fig. 11, does not resemble in the slightest degree that described and figured by Graber ('77), but indicates an entirely distinct kind of motion. The action of the elevators, which are the principal muscles of flight, results in pulling the whole dorsum of the meso- and metathorax into the thoracic cavity, causing the wings to assume a vertical position. When the tension is released, the wing begins its descent by the expansion of the compressed thoracic contents. Both of the strokes are at the beginning somewhat in the nature of a recoil. The full depression of the wing is brought about by the action of the side muscles of the thorax, which, by contracting the body cavity, force the dorsum outward toward the back, elevating the inner ends of the wing-roots.

Although von Lendenfeldt's description of the structures is quite full, it is very difficult to identify his parts. Amans evidently experienced difficulty, and gave a new description, much more simple and quite easy to follow. His figures, however, possess more artistic beauty than structural accuracy. Von Lendenfeldt's figures are not better, for the parts that can be identified are grossly inaccurate. It can be safely said that the many small cuticular wrinkles and thickenings that gave occasion to von Lendenfeldt's errors, and the minute muscles described by him and by Amans as attached at various positions in the base of the wings, are of only subordinate importance in flight.

According to the account given above, the articulation in the case of the wing of a dragonfly is brought about by the expansion of the bases of the veins into a broad wing-root corrugated to correspond with the wing itself, and presenting two broad, flat areas; these become on the under side condyloid cavities fitting the ends of processes developed above the pleurites in connection with the interpleural suture. The inner ends of the wing-roots connect by a rather complicated thickening of the membrane with the deeply infolded and internally expanded edge of the scutum where the elevator muscle is attached.

Let us now turn to other insects and see to what extent, if at all, the articulations there found may be reduced to this same type. One of the insects described and figured by Amans, the common harvest fly, is quite favorable for study. One

species, *Cicada tibicen*, is not greatly different from the European insect studied by him. In this insect the metathorax has been very much reduced, the hind wings being scarcely more than appendages to the anterior pair, and having very feeble, if any, motion of their own. Only in the front pair do we find the articular structures in a truly functional condition. We therefore will not concern ourselves at this place with a comparison of two segments, but confine our consideration to the attachments of the anterior wings.

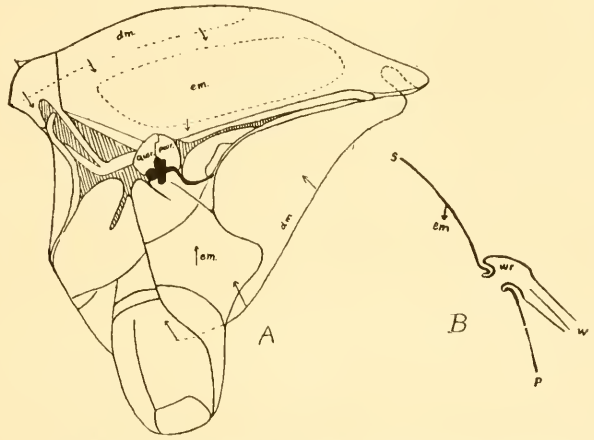

FIG. 12. Mesothorax of *Cicada tibicen*, showing wing attachment. A, from the side. B, section.

dm, depressor muscle; *em*, elevator muscle; *wr*, wing-root; *awr*, anterior wing-root; *pwr*, posterior wing-root.

At the outset we are confronted with a fact which can not but have a powerful influence in shaping the structure at the base of the wing. It is what is known as the flexion of the wing, a motion by means of which that organ is made to lie along the side of the body when at rest. This flexion, even in a small insect possessing a wing much constricted at base, can not be sufficiently provided for by the simple elasticity of the parts, because the bending must be nearly at right angles to the path of vibration, and so across the breadth of the wing, and because the flexed position must be that of rest. A rearrangement of certain of the basal structures is thus necessary.

The harvest fly will serve as a type of insects with flexible wings (see Fig. 59). In this insect there is a rather rigid wing-

root set in a cavity of the body wall, to which the wing is attached, and upon which it rotates during flexion. Eight veins may be recognized in the basal attachment of the wing. The first vein is the strongest one found in the wing. Its basal end is abrupt and does not articulate with the wing-roots, but continues toward the anterior root as a soft tubular sheath of the distal portion of the extensor muscle. This vein is closely appressed to the second, but is, through much of its course, always distinct from it.

The second vein is about equally prominent on both sides of the wing, except near the base, where it is entirely ventral. Just before the base is reached the vein appears to split into two branches, the anterior of which may be considered as a cross vein binding this vein to the first. The posterior branch is doubtless the lower portion of the posterior wing-root.

The third vein resembles closely the fourth vein in dragonflies in its shape and distal connections. Proximally it lies almost directly over the base of the second vein and is continuous with the posterior wing-root above; in the same manner the second vein connects beneath. These two veins form the hinge for the flexion of the wing.

The fourth vein is very closely approximated to the fifth, except at the two extremities. Toward the basal end it becomes abruptly feeble, but rapidly widens again, and from some points of view appears double. The extreme base is formed by a vertical process that articulates above with the tip of the posterior wing-root.

The fifth vein is quite prominent, being dorsad of the fourth, and in connection with the sixth vein expands at the base into a broad, flat, elevated plate, that lies partly over the posterior wing-root, especially when the wing is flexed.

The sixth vein, besides uniting with the fifth in the formation of the plate just described, comes into close relation with the body by fitting into a groove along the side of the scutum and into the catch formed at the end of the postscutellum; it also is closely associated with the hind wing, forming the catch that holds the latter expanded. A portion of the posterior edge of this vein is black and fuses with the seventh.

The seventh vein lies close along the sixth, somewhat ventrad to it, and contributes to the formation of the catch for the hind wing. The whole vein really belongs to the posterior

fold of the wing and connects loosely at base with one of the floating sclerites of that portion of the articular membrane.

The eighth vein is the tracheoid margin of the membrane arising from about the middle of the seventh and continuing at the base into the edge of the postscutellum.

The body is highly specialized; only the mesothorax contains important muscles of flight, those of the metathorax being nearly rudimentary. The hind wings have only the feeblest motion of their own and depend upon the front wing, to which they are attached, for their effective action. The wing-root is conspicuous, though relatively small and compact. It is the only hard part connecting the dorsum and pleuron, except at the extreme ends of the segment. The exact nature of the joint may be seen in Fig. 12.

Contrasting this type of articulation with that seen in the dragonfly, we notice most conspicuously the much greater expansion of the notum. This corresponds with its greater importance in flight in insects with this type of articulation, and with the more complex and efficient union with the wing-roots. Almost as striking is the relatively small size of these roots, already alluded to. The separation of the notum from the pleuron is nearly as complete as in the dragonfly, but the wing-roots occupy scarcely more than a fifth or a sixth of the width of the articular opening, the remainder being closed by soft, flexible skin.

Not only in these more conspicuous matters are the structures unlike, but when one examines the details, a difference will be noticeable in every item. The differences are so numerous and so great that it is difficult to conceive either to have been produced from the other; they point to a differentiation at a time when the wing-root had not been specialized. Starting with such an articulation as occurs in the base of a gill cover, either form of wing-root could have been developed, but only by growth along different lines.

In the evolution of a wing the wing-root must first arise as the result of a thinning of the wing membrane, making the organ everywhere very delicate except at the base, where there must be greater strength. The further perfection of the wing-root consists either in the thickening of the bases of all veins, so as to produce a single solid piece, or in the thickening of only those veins which come in direct contact with the bear-

ing points of the primitive wing. The form of the connection with the notum will be essentially different according to the method followed. When the wing-root is developed from the veins immediately adjacent to the bearing points, the structure will admit of greater movement at right angles to the direction of the stroke. The perfection of this type of articulation permits the complete flexion of the wing and requires provision for its expansion.

The attachment of a flexible wing usually shows three strong veins, as in the insect just described and shown at the

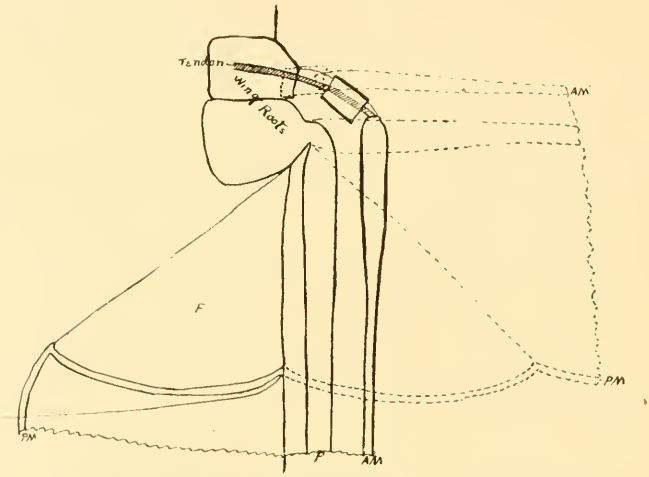

FIG. 13. Diagram illustrating the flexion of a wing. AM, anterior margin; PM, posterior margin; P, primary vein.

three black areas in Fig. 12. These three consist of the vein I have called the primary and usually the one immediately in front of or behind it, which at the base takes a position directly above or below the primary, the two forming the hinge for flexion, and in front of these a third vein, which is broken in one or more places near the base by soft, elastic, telescopic sections and is connected by a tendon to the extensor muscle, within the thorax. Behind the hinge all the veins stop short and are separated from the body by a flexible area, in which there are usually developed a number of floating articular sclerites very variable in shape, number, and position. Their weakness and variability prove them to be of very secondary importance in flight, but they will doubtless show, when more fully studied, a distinct and important relation to the

character of the basal fold. The accompanying diagram (Fig. 13) will show the characteristics of this form of articulation.

There is considerable variability in the exact structure of the wing-roots, probably corresponding with peculiarities in the shape or stroke of the wing, and the same is true of the accessory sclerites of the articular membrane. We will not attempt to describe or discuss them, as they do not appear to affect the venation of the wing. These two types of hinge structure correspond with essential differences in venation, and, notwithstanding their variability, exhibit nowhere transitional conditions.

Résumé.—In conclusion, we may remark that there remains abundant opportunity for study in the structures about the base of the wing. An examination of the structure of the articulation of the wing of a dragonfly has shown many points of difference from the accounts and figures of previous investigators. It proves also that the former ideas of the mechanism of the wings must be considerably modified. Likewise, a study of the articulation of the wing of a harvest fly brings out sufficient differences from the account of Amans to disprove his contention that there is no essential difference in the hinge structure of different insects. That there are two distinct types is further shown to depend upon differences in the probable course of the development of the wing-roots. Finally, it is pointed out that this corresponds with important differences in venation.

PART II.—VEINS AND VENATION.

VEIN STRUCTURE.

Before it is possible accurately to discuss the problems of venation, it will be necessary to inquire into the nature of a vein, in order to determine whether we have to deal with a single type of structure or with a number of fundamentally distinct, though superficially similar, organs. The majority of authors have accepted one or the other of these views, without, however, discussing the question. As a consequence they are often inconsistent, and in most cases have evidently given the subject very slight consideration. The points upon which differences of opinion have been expressed are as follows:

1st. It has been repeatedly maintained that such structures as occur toward the tip of the wing of a beetle are not veins, because they possess no lumen.

2d. Most of the authors treating of the wings in Neuroptera, Orthoptera, and, to a less extent, in other orders, have made a clear distinction between veins and cross veins, not classing them in the same category, chiefly because of the variableness exhibited by the latter.

3d. A difference is often made between cross veins; certain ones that are very constant in position are supposed to be somewhat different in kind or origin from the ordinary and more variable ones.

4th. In a few groups where long veins are numerous, most of those that are variable are supposed to be different in kind from those that are more constant.

5th. Very generally veins that arise from the base are considered as distinctly different from those without evident basal connections.

6th. Veins appearing as branches of another vein are often treated as of a different kind from those whose inner end is free or connected by only a cross vein with principal vein.

7th. The vein that lies along the margin is often distinguished from the other veins, sometimes by evident difference in structure, sometimes because of its position, especially when it

makes a complete circuit of the wing and has two basal attachments, or finally because it often differs from the other veins in having no tracheæ in the early stages of its development.

8th. This last argument has been carried so far as the maintaining of an entire difference of nature between all veins developed about tracheæ and those without tracheæ.

9th. An entire difference of nature has been maintained for veins occupying elevations or depressions of the wing membrane.

10th. A similar distinction has been made between veins according to the proportion of substance contributed by the upper and lower layers of the wing membrane.

11th. Again, a row of hairs or spines, a fold of the wing membrane, or even a disturbance of the pattern, have been held to be potential veins, though showing no other evidence of vein structure.

12th. Finally, the true vein has been supposed to lie deeper than the skin and to have no necessary connection with any of the surface indications.

A typical vein is a tubular structure, the wall of which differs from the wing membrane by its firmer texture, by more or less evident peculiarities of pigmentation, both in its own substance and in the adjacent parts of the membrane, by peculiarities in the surface ornamentation, especially in the shape and arrangement of the surface hairs, and by the presence in its lumen of body fluid, a tracheal trunk, a more or less evident quantity of connective tissue, and occasionally a nerve. Ontogenetically the vein is a region of arrested development—a region in which cells are proliferated, but not specialized. The cells of the vein merely remain more like those of the body wall than do the membrane cells, and for this reason retain the power of chitin production unimpaired. Not only is the chitin production similar to that of the general body wall, but the pigmentation is also quite comparable. In position the veins probably in every case represent wrinkles in the embryonic wing membrane, but it is often difficult to make this out. The lumen is simply a continuation of the body cavity into the wingpad, brought about at first mainly by the smaller size of the vein cells, as compared with the membrane cells. The position of the vein at the angles corresponding with the folds of the membrane and the crowding, and consequent bowing out, aid in keeping the cavity open.

Nearly all the structures that appear as veins in the higher groups—Diptera, Hymenoptera, and Lepidoptera—are veins according to almost any criterion that may be used, and may be taken as the standard for determining the soundness of the criteria proposed. We will now consider in detail the significance of the characters suggested for the recognition of veins.

The presence of the lumen has been a very common test ever since the name came into general use. This is particularly true with English entomologists, who follow Westwood in the belief that flight is only one of the functions of the wing, and that another of great importance is the aëration of the blood, the veins being supposed to afford especial oppor-

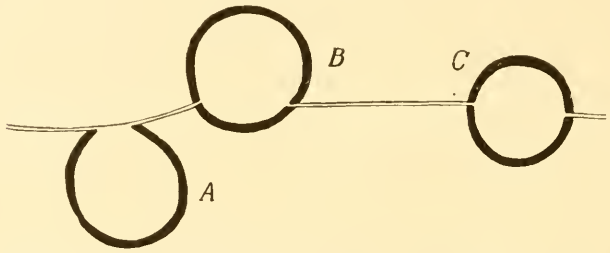

Fig. 14. Diagramatic section of a wing of *Cicada* near the base, showing three principal veins in cross-section.

A, a vein belonging entirely to the lower membrane. B, one largely formed by upper membrane; and C, a vein about equally divided between the two membranes.

tunity for its accomplishment. If this is true, the lumen is of prime importance. No evidence, however, has ever been advanced to prove that the blood could receive any appreciable amount of oxygen from the outside air through the vein walls, even when the veins have large cavities. The circulation of the blood through the veins is in most cases an impossibility, because they are not continuous channels.

The supposition that the vein function is the aëration of the blood is not necessary in accounting for the shape of the vein. There are two other explanations for the development and maintenance of this shape. One of these is that the presence of the blood in the wing prevents the drying of the wing to such an extent as to make it brittle; a condition which is quickly reached in dead insects. The other explanation is of greater importance, namely, that a tubular form combines the greatest strength with the least amount of material.

In this connection it should be recalled that a vein (Fig. 14) is produced in halves, one in each membrane, and that the lumen is the result of their not fitting together closely, they being arched in cross-section. Sometimes the curvature exists in only one membrane, the other contributing merely a flattened plate, which is sometimes only slightly or not at all thickened. There is no essential difference between these one-sided veins and symmetrical ones, as all transitions occur from a case where a vein is shared equally between the two lamina to one where, so far as any appreciable structure is concerned, it belongs wholly to one membrane. This transition may sometimes occur in the course of a single vein.

The apical end of a vein, especially in Hymenoptera, is often solid; that is, the lumen ends long before the tip of the vein is reached, and there is no change in any of the other characteristics of the vein. These peculiarities may be seen in Fig. 15. The structure in the latter case is unquestionably identical before and after reaching the point where the lumen ceases, and for some distance both lamina contribute to the formation of the solid vein; finally, when the wing appears to involve but a single layer, there is still no change in structure, only a gradual diminution in size, which begins long before the lumen disappears, and is uniform and regular all along its course. Furthermore, there is a great deal of variation within a species regarding the point where the lumen ceases. In some species the lumen may extend to the extreme end of the vein; in others, it may not exist beyond the point where the vein leaves the cross vein.

FIG. 15. Portion of the hind wing of *Apis*, showing veins becoming solid.

The evidence is thus sufficient to support the proposition that the presence or absence of the lumen does not indicate any essential difference in the nature of a vein, but signifies, rather, different conditions of the same organ.

The presence or absence of a trachea in the vein has appeared a matter of more significance, especially to German and American entomologists, on account of the association of the wings with tracheal gills. Not a few writers have supposed the vein to be merely a specialized trachea. The only basis for this idea is the tracheoid character of many veins.

This condition is seen in all wings in the delicate vein that borders the posterior basal membrane and connects with the edge of the postscutellum. It comes out sometimes very distinctly in parts of the vein where folds occur (Fig. 16). In many cases a whole vein will become tracheoid, and occasionally all the veins of a wing take on this character. Whether a vein is tracheoid or not is a matter independent of its homology, as the character may occur in wings of any group of insects or in any particular vein.

Tracheoid thickenings occur in both membranes independently of each other, as may be most clearly seen when halves of the vein fail to correspond exactly in position, as is not uncommon in Psocidæ. In the accompanying figure (Fig. 17),

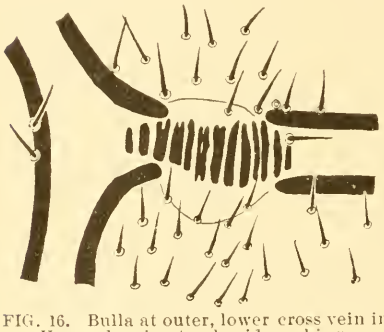

FIG. 16. Bulla at outer, lower cross vein in *Vespa*, showing tracheoid markings.

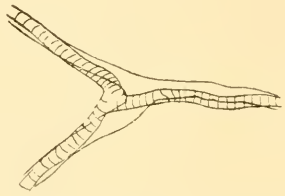

FIG. 17. Portion of *Psocid* wing, showing nonconformity of halves.

where, to prevent confusion, the tracheoid structure of only one lamina is indicated, the tracheoid ridges of the two do not correspond. The shape of the two forks also shows that in this particular case the half veins themselves could not have been made to superpose.

In their ontogenetic origin the tracheoid markings of veins are due to excessive chitinization of the outer edges of the transverse folds of the layer of cells that in the pupa produce the veins. The markings consist of thickenings of the cuticle which project on the convex side of the vein. It is these ridges that, in the wings of crickets, are made use of in the formation of the stridulating organ. They are developed in the same position as is the hairy or scaly clothing of the veins, and are related to the spines which sometimes replace the hairs on the wings of insects. The wing-clasp of the front wings of the species of *Psocus* illustrated in Fig. 18 shows a very interest-

ing modification of the tracheoid ridges. Here is a vein that is conspicuously tracheoid on the lower side of the wing, but free from these structures on the upper side. The tracheoid structure is entirely normal along most of the wing, but toward its tip the ridges begin to project as spine-like processes from the outer margin of the wing. These processes are successively longer and longer, till finally those nearest the end curve over and form the clasp that serves to hold the two wings together. At the region of the greatest development of these spines the vein itself almost disappears, all the cuticular substance appearing to be appropriated for the production of the modified spines.

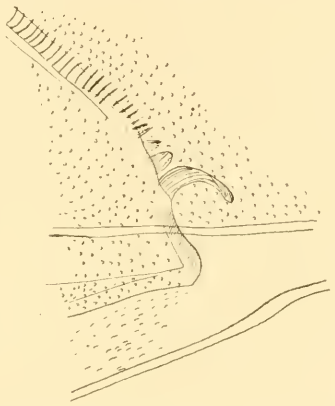

FIG. 18. Clasp on front wing of *Psocid*, showing relation to tracheoid thickenings.

Tracheoid structures can not, in view of these facts, be connected with the trachea, nor are they criteria for the recognition or classification of veins, but simply methods of specialization, and might be produced at any point when the appropriate conditions occur. What these conditions are can at present only be guessed at, but we may have a clue to them in the common presence of tracheoid growths in bullæ. These appear to be simply collapsed portions of veins whose cells have failed to produce sufficient chitin. It is conceivable that such cells would have a lower osmotic pressure and therefore a greater tendency to cling together, so that relatively less chitin would be deposited in the depths of the transverse wrinkles of the developing wing in this region. The facts that weak veins exhibit a greater tendency to develop tracheoid characteristics, and that in a single vein regions which are suddenly narrowed often show the same tendency, agree well with this hypothesis.

To return to the question of the true tracheation of veins: we have to deal with a matter that goes back to the early stages of the development of a wing. The chitinization, which is the most evident thing about a vein, is produced only just previous to the last molt; but the vein cavity is evident long

before this time and is usually already occupied by a trachea. In some insects the vein cavities are clearly distinguishable for a considerable period before the tracheæ enter them, while in others the tracheæ can be recognized before the vein cavities appear. In these cases it is impossible to deny that the location of the veins may have been really marked out, though unrecognizable to the eye; but if so they were really established before the entrance of the tracheæ, as in other insects. It is probable that the tracheæ enter the cavity between the laminæ and assume their fixed relation to the structure of the walls, though they later occupy vein cavities.

It is the contention of those who insist upon a close relationship between the veins and tracheæ that the presence of the tracheæ causes the change in the cells close to it which results in the production of the vein. In the cases where the tracheæ are not present, or only later enter these cavities, the supposition is that the veins, while originally requiring the presence of a trachea, have reached a condition in which they no longer thus depend on tracheæ. How such adjustment can be brought about has never been explained, and until it is, the facts must be considered as throwing a great deal of doubt upon this explanation.

There is reason to believe that the presence of a trachea produces a different environment for the neighboring cells; but the fact is, that there is no appreciable difference in the structure or appearance between veins which enclose tracheæ and others in the same wing which are devoid of them, and that there is likewise no difference between the regions of the membrane which are traversed by tracheæ and those which are distant from them; all goes to show that the influence of the tracheæ extends far enough so that all parts of the wing are in practically the same condition in this respect.

A trachea always takes a more or less sinuous course through a vein, never conforms to the short, abrupt turns the veins often make, and does not exhibit any evidence of closer relationship to the vein than that which exists between the tubular antenna or leg and its tracheal trunks.

Evidence has already been cited discrediting the idea that the wing performs the functions of a respiratory organ; moreover, the course pointed out as probably that of the phylogenetic development of the wing—which gives the vein an

origin in the precursor of the wing entirely distinct from the tracheæ—suggests the idea that no essential relation exists, or ever has existed, between these structures.

This view is further supported by the well-known fact that there is considerable variation in the tracheation within a group, certain veins being in some cases with or in others without tracheæ, though otherwise not different, and particular veins being served from entirely different tracheæ. These variations occur in the lower groups, as well as in the higher; in the former at least, a definite and constant relationship should be maintained.

A large amount of very strong evidence would be needed to explain away the essential identity of structure in tracheated and non-tracheated veins; the evidence obtainable seems all to indicate identity rather than difference. We must conclude, then, that the presence or absence of tracheæ is an incident of structure of no special significance in comparing veins.

Other evident differences in the structure of veins and in the degree of constancy in structure or position within the same species or small group, where homology is easily traced, have given occasion for the idea that there are two different kinds of veins. But the line separating these two sorts is placed differently by different authorities, in the ways already pointed out. The structural differences in addition to those already discussed in this section are mostly matters of size and pigmentation.

In reference to the size of veins, it is only necessary to point out that while, in particular cases, veins can be readily grouped into two classes on the basis of relative size, still one need go but a short way in the study of related forms to find that this character is of no significance. Longitudinal and cross veins are the ones in which differences of this kind most commonly occur. In most cases no decided difference can be made out, and often where cross veins have become parallel with the costa they are so similar as to be easily confounded with true longitudinal veins.

The pigmentation of veins is a very characteristic and rather complicated matter. We must recognize at least three topographically distinct regions of pigmentation as occurring on veins. The pigments of these three regions are very uniform, all being brownish or black oxidization products in the cuticle,

like those in that of the body wall. A difference of intensity can generally be recognized, often bringing these three regions into very sharp contrast one with the other. Pigment may be absent from any one of these regions, but some pigment is always present, unless it be in the case of very small wings in which the veins are presumably degenerating.

The first region of pigmentation is the one usually seen as a uniform tint over the vein surface. It is often more feeble than in the other regions, but sometimes persists when that of the others is not recognizable at all. This may be seen most evidently in veins without lumina. Sometimes when the other regions are well pigmented, it is evident only locally, as illus-

FIG. 19. Portion of wing of *Apis*, showing different kinds of pigmentation at bulla.

FIG. 20. Bulla in wing of a wasp.

trated in Fig. 19. A differentiation of the surface pigmentation may be seen in the case of tracheoid veins where the surface elevations are very much more densely colored than the intervening hollows, thus bringing out the structure of the vein very plainly. This may be seen in Fig. 16.

The second and third regions mark the border of the vein and are not always readily distinguishable from each other. The former lies within the substance of the vein, while the latter belongs to the wing membrane. Sometimes one is more prominent, sometimes the other. Differences come out most conspicuously in the bulla. The second region either stops abruptly or narrows into a sharp, but pale line marking the edge of the lumen, while the third shows a tendency to spread out and follow the fold, as seen in Fig. 19, or narrows into a line similar to that of the second region, as may be seen in Fig. 20.

The fact that there are three kinds of pigmentation and that these may occur in almost any combination as regards their relative distinctness, affords abundant opportunity for apparent differences in structure. One can commonly trace on a single wing, sometimes in a single vein, a large number of variations in pigmentation. Interesting examples of this are very common in the wings of the higher flies and of beetles.

A very careful study of the pigmentation of the veins supposed by different authors to represent different types of veins has failed to reveal a single constant item of difference in any case when a sufficiently large number of wings were studied. The pigmentation of the same vein differs in many cases according to the size of the wing, indicating that perhaps the size of the vein cavity may have something to do with the amount or character of pigmentation. However this may be, it is safe to say that there is no evidence that the pigmentation indicates in any case differences of structure by which types of veins may be differentiated.

There still remains for consideration that class of so-called veins which are represented on the wing either by the arrangement of the surface hairs, by the disturbance of the color pattern, or by folds in the membrane.

Hairs usually occupy a very definite position in relation to veins. Usually the surface over the vein is either devoid of hairs, or possesses one or several rows of them regularly arranged, often of a larger size than those on the membrane, and sometimes of a peculiar structure. Whenever there are on the surface of the membrane rows of hairs similar in structure and arrangement to those on the veins, their position is always such that if a vein were to replace them, it would not be considered anomalous in position. The very common presence of hairs on veins, except such as have been just described, gives very good grounds for thinking that they could not be produced except over cavities like the vein cavities, and therefore that they represent veins either suppressed or not yet perfected.

The pattern on a wing, whether due to coloration of the membrane, or, as in Lepidoptera, to the presence of colored scales, often shows a very distinct irregularity where a vein crosses a spot or band. This is conspicuously evident in the bands along the outer margin of the wing in most Lepidoptera.

Now, in the area in front of the second posterior vein, although there is no vein traversing it, the band is interrupted, in many cases at least, in just such a way as it would be if a vein were present. In this particular case students are pretty well agreed that this really represents a lacking vein.

Folds undoubtedly have a close relation to veins. If comparisons be made between two closely allied insects in the wing of one of which there is one less vein than in the other, this lacking vein, except when near the margin, is always found to be represented by a fold that occupies the same position as the vein. On the other hand, there are many folds in the membrane of the wings of insects that are never represented anywhere by veins.

Each of these three modifications of the membrane is thus seen to indicate relationship with veins. The question arises, Do they represent veins that have disappeared, or are they places where veins are in the course of development? The fact that the lower insects commonly have more veins than the higher has led many observers to the conclusion that these modifications represent lost veins. In some instances this is very evidently the case. A broader view of the matter would be the conception that there is between every two veins a possible vein-path, or more than one, and that these may be indicated by either of the peculiarities we have just been considering, and that there is no essential difference between the indications of a forming vein and of a suppressed one. This path partakes of many of the characteristics of veins, so that the calling forth of a new vein is not a process that must result in an entirely new structure, but there is at hand a region almost ready to take on that kind of development. Likewise, the suppression of a vein involves merely the lowering a little of the conditions that increase the tendency toward vein development. These paths of potential veins exist in all possible conditions from nothing to a complete vein. The suppression of a vein may be supposed to involve the reduction of the adjacent vein-paths to the minimum, and their replacement by a single path that represents the destroyed vein; the formation of a new vein to involve the development of two new vein-paths.

Résumé.—The many diverse conceptions of the structure of veins, which have been based on the assumption that other

vein-like structures exist in the wing which have nothing to do with veins, prove, upon analysis, to be untenable. The typical vein structure is connected by a complete series of intermediate forms with all the other vein-like structures in the wing. The lumen is merely the space left between the semi-cylindrical halves, and disappears if these two elements remain flat. Tracheoid structures are simply modifications of one or both of the layers and are exceedingly variable. Tracheæ likewise are found to be variable enough to discredit their importance as means of defining veins. Neither size nor pigmentation affords any better method of distinguishing foreign elements in a venation. On the other hand, the less tangible influences, such as are expressed in folds, hairs, and color pattern, do conform to and belong to the venation scheme.

VEIN DEVELOPMENT.

While many investigators have studied the development of the wings of insects, most of the principal groups having received attention, practically nothing has been given, even incidentally, upon vein development. Doubtless the reason for this is the fact that most of these investigators have been concerned with the question of the origin of the wing, the method of its expansion after molting, the clothing scales, or the tracheation; all matters much more conspicuous than vein development. While there is nothing peculiar enough to have attracted students to the study of the formation of veins, still, for the purpose of the present study, the matter becomes of more than usual interest.

The development of the wing, in most of the lower insects, begins by a slight modification of the "margin" of the meso- and metathorax, though sometimes, as in Odonata, where there is no "margin," by a minute tubercle; in the higher groups, by a much more complicated process involving an invagination of the tegmentary epithelium and a subsequent evagination of the organ like that which occurs in other imaginal disk-producing appendages. In the lower groups of insects the cells of the wingpad are not distinguishable in any respect from other hypodermal cells in similar situations, such as those in the narrow fold at the posterior edge of most segments. In the invaginated wings the cells are very different from those of the body wall, but not distinguishable by any histological

peculiarities from those of other similar invaginations, as for instance, those of the legs. The wing disks, as a whole, are from the first different in shape from other invaginations, and thus distinguishable from the leg disks; later the arrangement of the different sorts of cells that compose them is characteristic, and ultimately they are distinguishable by the structure itself of some of the cells; but this is not true of the wing fundaments when first developed.

All wing fundaments are alike to the extent that they are sac-like organs and that the mouth of the sac opens into the general body cavity. Being thus open the sacs always contain blood and are accessible to ingrowths of tracheæ and connective tissue; the latter forms in many cases an investment of the deep ends of the cells which constitute the wing membranes, and is generally conspicuous when the wing is young. This investment has been noticed by several authors in widely different groups, and may occur in all cases. Ultimately this connective tissue may partially or wholly disappear, or may in other cases increase in amount and contribute not a little to the stiffening of the wing. An extreme case of this kind may be seen in the front wing of *Belostoma*, where it extends as a strong layer across the whole breadth of the outer third of the wing and is thickened at the vein so that if the whole cuticle is stripped off (after loosening it in caustic potash) a complete venation and membrane still remain. In this case the cuticle over the vein differs from that elsewhere only slightly if at all, so that it would be difficult to make out the venation from the cuticle if it were taken off and examined alone. The chitinization of the connective tissue here is more complete than that of the cuticle itself, so that it is harder and more resistant to the action of alkalies.

The presence of nerves associated with tactile hairs or other sense organs has often been noted in company with the veins. They need not be treated of in this place, as they are not uniformly present in veins, and certainly are not a necessary or important component of them.

The problematical "rods of Semper," that have been repeatedly described in Lepidoptera, are only imaginal tracheæ in the process of development and not essentially different from any other tracheæ in insects' wings.

In studying the development of veins we need only to take

into consideration the constant features of a developing wing, the hypodermis of the wingpad, and the cuticle that it secretes.

The first trace of the venation in a wingpad is a series of slight separations between the two layers of hypodermis running lengthwise of the pad. Exactly when this arises is difficult to make out with certainty; it may exist from the very first, but the indication is so slight that one can not be sure of its presence until the cavities have attained considerable size. By this time the veins can be seen in surface view as well as in sections. In surface view they appear as slightly paler stripes with no definite boundaries. They are from their first appearance in a position approximating that which they occupy in the adult venation. The paleness of the bands is doubtless due to the transparency of the blood in the vein cavity. The vein cavity hardly becomes distinguishable before a difference begins to appear between the cells of the vein region and those pertaining to the membrane. The difference is chiefly one of size, perhaps wholly that.

The early details of the development of the wing vary greatly and in many particulars in different insects. An important difference that distinguishes the lower insects from the higher is the fact that, in the former the wingpad takes part in each ecdysis, whereas in the latter the wings part from an old cuticle only at the molt by which the insect becomes adult. These two processes of growth are not so fundamentally different as they at first appear to be, because a complete transition between the two types is afforded by a single order, the beetles, indeed in one case by individuals of the same species.

In order to take part in the ecdyses, all the hypodermal cells must retain the same power of secreting chitin until the pupal stage is reached. Up to this time the smaller vein cells are neither more nor less active in this respect than the larger cells of the membrane. The differentiation of the vein and membrane cells in the early stages is very incomplete, and they remain thus similar almost without further change until after the penultimate molt. In some cases the veins appear as wrinkles in the cuticle of the wingpad, but in other cases the wingpad remains smooth in all the stages. When the wrinkles are present, we can consider the wing to have progressed in its development to an ontogenetically later condition, but it appears to be in nowise a gainer by this precociousness.

The cuticle of the wingpad is quite uniform with that of the rest of the body, and is simply continuous, at the base of the pad, with that of the thoracic wall, there being no articular thickenings. When the wrinkles of the veins appear, one can also see signs of the developing hinge structure of the wing. In those insects in which the pupal wingpads are cemented to the body, the cuticle of the inner (ventral) side is much thinner than that of the outer (dorsal) side, but there are no differentiations indicating the veins except wrinkles on the dorsal side.

The increase in size at each molt is provided for by a series of wrinkles of the layers of the hypodermis, in the same way, and to much the same extent, as occurs in other parts of the body.

Thus we see that up to the entrance upon the pupal condition the development of the wings had not been carried forward any considerable distance. Within the pupal wingpad the organ continues its development in a very leisurely way, coming to its perfection only just before the insect is ready to emerge as an adult. The wing just before the last molt is a striking example of close packing. The veins, though composed of thick cuticle, are stowed away so that they occupy only a small fraction of their length when extended. This is accomplished so exactly alike for both the dorsal and ventral faces of the wing that when expanded the two correspond in every detail.

Since the veins are nearly all produced in two parts it is necessary for their completion when in position after the final expansion of the vein that they superpose with great accuracy. This requires that the cells of each intervenous area shall develop a cuticle of the same size in the two surfaces. This coördination of the two membranes I believe to be brought about by the direct contact of corresponding cells. The fact that the deep ends of the cells composing the two hypodermal layers are united has been figured and described for several groups. In some groups this is supposed to be brought about by the connective tissue, while in others the cells of the two hypodermal layers are figured as actually touching each other. From my own preparations I believe that both methods are to be met with.

The size of the wing seems to determine to a considerable extent which of the conditions shall be realized. The best

figures of the condition of the cells in the larger insects are given by Mayer ('96). The section shown in Fig. 21 illustrates the cell arrangement in one of the smaller leaf hoppers. It is always difficult to make out exactly what the nature of the union of the cells really is, except in the smaller forms, where there is no real connection, but only close contact.

FIG. 21. Cross-section of wingpad of nymph of *Typhlocyba comes*, showing vein cavities

Usually the correspondence of the two parts of the vein is apparently exact, but one can easily find abundant examples of a failure to meet, such as is shown in Fig. 17. A more common condition is where there is a considerable difference in the relative size of the parts on the two sides of the wing; the small part, occupying any position from side to side of the larger section, though in this case the veins give one the impression of perfect conformity, except when examined very carefully. The possible range of variation of this sort, before the nonconformity would ordinarily be discovered, is often more than half the diameter of the vein, and cursory examination might even fail to distinguish a displacement that is not distinctly more than the diameter of the vein.

The difficulty of the problem arises from the fact that the wing is not developed flat, but wrinkled to a remarkable degree, especially in the membrane areas, where, in addition to the transverse wrinkles, found also on the veins, there is still greater folding in a longitudinal direction, providing for lateral expansion. This difference in the character of the folding, when it is developed just before chitinization, is the most evident difference between the vein and membrane regions of the wingpad. Probably the wrinkling was at first irregular; that is, with no definite arrangement, but more or less uniform over the whole wing; with the development of veins, the greater need of room for the thicker cuticle of the vein regions gradually led these regions to be folded in one plane only; the membrane areas, on the contrary, retain the irregular method of wrinkling, and to compensate for want of lateral wrinkling in the vein areas, suffered an increased degree of wrinkling in the lateral direction. With all the changes incident to this readjustment, it is necessary that the cells of the two sides of

the wingpad shall everywhere develop alike. This seems possible only when the corresponding areas lie strictly opposite each other.

It is not necessary that each individual cell be connected with a corresponding cell on the other side, but only that enough points of attachment exist to insure the general correspondence of the areas, and, in larger wings, of the principal folds. Mayer has pointed out the utility of these connectives at the time of the ecdysis, but no one has suggested their evident primary function, that of correlating the position of the cells in the wing membranes.

The relation of the hairs and scales to these folds is very evident, those of the membrane areas being at the peak of somewhat conical elevations produced by the double folding If the folds of the two sides of the wing exactly correspond, the hairs or scales in the imago would exactly match. In some insects this is true to a degree that is marvelous, scarcely a single hair in the whole wing being without its mate, both so perfectly placed that in focusing, the transition from one set to the other may be easily overlooked. In other insects there is no evidence of any relationship, showing that the connection was of the most general kind. In Lepidoptera there is usually a general conformity, but seldom a very strict one.

On the veins there is never the precise opposition of hairs or scales that is sometimes seen on the membrane. However, when they occur in rows, there are generally in a given distance the same number on the two sides. This condition corresponds with the entire absence of connection of the two sides in the vein region and to the equality in the size and number of the folds upon which the straightness of the vein depends.

The hairs or scales lie much closer together in the membranous region of the wingpad than they do on the veins, for the reason that the veins do not expand laterally at the time of emergence, and this probably explains their differences in structure, usually so evident. One of the functions of the stronger hairs of the veins is doubtless to aid in the molting process. Even in the case of Lepidoptera the vein scales, though appearing much like the others, are very much stronger, because of their thicker walls.

Thus far we have designated the corrugations of the surface of the wingpads as wrinkles or folds. This should be explained before we begin to consider the production of the cuticle, for this structure more properly than the hypodermis might be spoken of in these terms. To avoid confusion, therefore, we must point out that when speaking of the cell layers reference is had only to the condition of the outer surface of the cells. The deep surface may or may not follow the course of the outer surface, and at best does so only approximately.

The so-called foldings of the cellular layers is rarely or never a folding in the true sense of the term, since it does not involve the lower halves of the cell, but is brought about by a rearrangement of the outer ends of the cells such that the outer surface presents a series of ridges regularly alternating with furrows. It occurs immediately before or at the time of the beginning of chitin production. The chitin is a layer which is so molded over ridge and groove as to be thrown into folds. The regularity of the cell grooves would at least suggest that they passively result from the real folding of a plastic layer of some kind, its folds being caused by lateral pressure. The cuticle itself when first formed, or rather the outer portion of it, might possibly serve as such a layer.

This hypothetical layer might be supposed to meet with too much resistance along the veins to allow the production of longitudinal wrinkles in addition to the transverse ones. The latter may be supposed to arise first, because a short wrinkle across the wing is more easily formed than one lengthwise. By this assumption may be explained the manner in which such a complicated wrinkling as occurs in the membrane could result in the production of a flat membrane after it is expanded.

The possible history of this hypothetical layer is that it is produced as a uniform homogeneous layer over the surface of the wingpad cells before they begin to show any wrinkling whatever, and that it then swells by the absorption of water or some other material originating in the cells beneath. Thus arises the lateral pressure that throws the whole layer into folds. The cells separate along lines where the folds press upon them, thus bringing about the grooving of the cellular layer. The importance of the connection between the cells of the two walls of the pad in maintaining uniform conditions has already been dwelt upon. If the connection is intimate, the

two wrinkling membranes would find the points of resistance practically identical on the two sides, and so might produce sets of foldings sufficiently the counterpart of each other to accomplish the coördination of the two membrane areas (Fig. 22, B).

The amount of expansion necessary in our hypothetical layer would not be as great as is usually estimated. From a number of measurements of wingpads and adult wings, it appears that an increase of from three to four diameters would be sufficient. Even this is very large as compared with the power of most substances to swell, but certainly not impossible. Whatever the cause of wrinkling may be, it is without doubt the same all over the body of the insect. The folding of the hypodermis in the wingpads is different in degree, but not in kind, from that which accompanies increase in size elsewhere. Just before each molt the hypodermis secretes two substances of peculiar nature. One is watery, or slightly mucilaginous, and serves first to separate the old cuticle from the cells, preliminary to the production of the new cuticle, and acts as a lubricant during the process of molting. The other is chitinous, but of a peculiar kind, clearly distinguishable from the remainder of the cuticle. The nature of neither of these substances is understood, and one of them may represent the hypothetical layer.

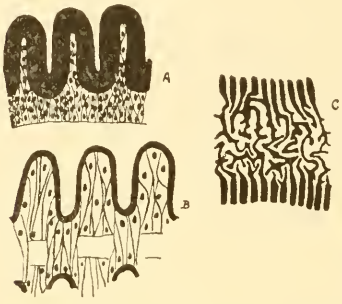

FIG 22. Diagrams illustrating folding of wings at time of development of cuticle between two veins of *Typhlocyba comes*. A, longitudinal section of vein; B, of membrane; C, tangential section of membrane.

The hypothesis thus offered as an explanation of the grooving of the developing veins and wing membrane is, in brief: (1) That there is secreted by the hypodermal cells shortly previous to each molt a substance that by swelling throws itself into folds, and where the hypodermal cells are in the right condition insinuates itself between these cells; (2) That there is produced at once a new cuticle, which follows down into each of the grooves thus formed, but straightens out as soon as the insect emerges.

The production of the cuticle on the vein areas presents no very peculiar features. It proceeds at the same time and in the same manner as the cuticle production on the membrane, from which it differs simply in being thicker. There must be differences in the chemical composition of the cuticle in different regions, as is shown by the development of color after emergence, but this is not evident to the eye at first. The cells are not usually so completely exhausted by cuticle production as are those of the membrane. They thus often form a considerable layer around the inside of the expanded vein.

After the final molt all the folds of the cuticle straighten out, the membranes of the two sides flatten against each other, and after drying are usually hardly distinguishable as two layers. The veins, at first flat, soon become tubular and harden in that shape.

Résumé.—According to this account the development of the vein begins with cells not at all differentiated from those of the body wall, but constituting a sac, opening into the body cavity, which may or may not be associated with tracheæ, connective tissue, etc. The first trace of a differentiation is the formation of the vein cavities, caused chiefly by a slight shortening of the cells of these regions. The differences between the development of veins in higher and lower insects are not important, as in all cases scarcely any progress is made in development until the penultimate stage is reached, in which the two types closely resemble each other. Even in this stage the veins are scarcely different from the membrane, except in the matters already mentioned, and this condition persists until near the last molt, when the grooving occurs. The veins fold only transversely, while the membrane wrinkles in a very complicated manner in both directions. An explanation of the folding is attempted by assuming the secretion of a layer that swells, and molds the outer cuticle-producing surface into an appropriate shape, and thus provides for the ultimate expansion of the wing into a flat organ. The cuticle production and the expansion of the wing then proceed in the manner that is normal for expanding regions in any part of the body.

GENESIS OF VENATION.

There are two chief groups into which the problems of the origin of venation may be assembled. The first includes the general questions of the formation of venation of the primitive wing and the means and methods for the correlation, modification, and adaptation of the veins that are the units composing it. The second group comprises the data bearing upon the formation of the special types of venation found in the different orders and families of insects.

As belonging to the category of general questions, we shall first discuss the theories and conceptions upon which have rested the schemes of venation that have been current. All the earliest systems were based upon the very evident, indeed unmistakable, homologies existing in closely allied forms. Names were given to the veins according to the needs in each particular group, in some cases without regard to the nomenclature employed in other insects. The belief was quite general that there was an essential unity in the venation of all insects, and numerous attempts have been made to apply the terms used in one group to the veins in other groups. The great difficulty of tracing homologies in insects only distantly related accounts for the tangle that has resulted. What these early systems were, we shall not attempt to discuss until we come to consider the modifications in the separate groups. For the present purpose it will be sufficient to say that none of them represents any particular theory further than the names employed suggest, and that they were simply systems of nomenclature made for the sole purpose of rendering the wing characters available for classification.

After the general acceptance of the doctrine of evolution, and especially after the promulgation of the theory of Gegenbaur as to the origin of the wing, the venation came to be generally regarded as depending for its chief features upon the structure of the organ from which the wing was supposed to have been derived; the conception being, as has already been explained, that the veins are produced around tracheæ, and that these, and therefore the veins, simply reproduce the tracheal arrangement inherited from the organ that was the precursor of the wing.

If this view is correct, the surest and best means of study-

ing the homologies exhibited by the venation is to make out the tracheation of the wingpad. Comstock and Needham ('98–99) are the only ones who have attempted to put into practice in any extensive manner this plan of studying venation. They found that in several groups the tracheation could not in any manner be depended on for this purpose. In other cases, however, including most of the lower orders, these authors were convinced that the tracheation afforded the soundest criterion for the establishment of homologies.

The only other theory to account for venation that has been elaborated and seriously defended is that of Adolph, as follows: This author does not attempt to explain the origin of venation, but bases his explanation of the present condition on the alternate arrangement of the veins in two series, one occupying the crests, the other the depressions of a series of regular plications, best seen in the mayflies. He supposes that the more dorsal veins, which he denominates the convex veins, are different in origin, structure, and significance from the ventral (his concave) veins, and that the orderly alternate arrangement of these will aid in the recognition of obscure homologies. According to this theory the wing represents the fusion of two semi-venations alternating with each other. Adolph's theory does not appear to have gained many adherents, though it has attracted a good deal of attention and not a little criticism—first, by Brauer and Redtenbacher ('88), and later by many others. The idea has strongly influenced later students, even when they have rejected it as unsound. This is because it directed their attention to facts that are very evident and, as I believe, of unquestionable importance in the development of the venation of many groups, though exactly what they signify has never been clearly pointed out by any of my predecessors. I shall presently endeavor to explain their meaning.

Still another theory has been suggested, but not elaborated, in a recent work by Packard ('98). This latest idea is that the original venation was determined by the mechanical necessity of flight. Most authors have supposed that this factor has been an important element in the specialization of particular types of structure, but none had previously ascribed any of the features held in common by all types of wings to this cause. Packard does not explain any of the details of the genesis of venation in accordance with this principle, and

has not been entirely able to divest himself of his former idea of an essential connection between the tracheæ and veins, even after becoming a convert to the Müllerian theory of wing origin.

The mechanical theory of the origin of venation really affords, I believe, an explanation of wing structure much more reasonable and adequate than either of the other two suggested solutions of the problem. In an organ adapted for such a special function as flight, where the accurate adjustment of the mechanical detail is of such supreme importance, it is very natural to think that the structure upon which the strength of the wing depends should be more profoundly affected by its own functional requirements than by the accidents of the structure of a temporary adaptive organ occurring in an ancestor that lived in or before the Silurian epoch, particularly since the detail of structure of that organ could have been of no importance in the beginning, and can not have any ontogenetic necessity at the present day.

The more rational conception is that there existed at the beginning, and has existed through all time to the present day, a mechanical necessity, in accordance with which the primitive venation was produced and all its essential features have been maintained through all the vicissitudes of the ages. This idea accords entirely with what has been conjectured to be the course of the development of the precursor of the wing.

In this ancient organ we may suppose that the general outline of the venation of insect wings had already been blocked out, because that organ was called upon to meet similar needs. Exactly how far the venation was specialized before the organ became an organ of flight may never be known, and does not particularly concern the present discussion. The terms wing and wingpad will be used, in what follows, in the sense that they include the precursor of the wing.

Another matter that can not be followed with any assurance of chronological accuracy is the order of vein specialization, because there are a number of elements in a venation that are to a large extent independent of each other. In other respects the course of the development of venation can be traced very satisfactorily.

One of the earliest veins to appear is the marginal. Its ontogeny can be imagined by supposing the wingpad to have become somewhat more bag-like than usual after one of the

molts. Certain conditions of cell nutrition, probably those that decreased osmotic pressure, would result in a closer union of the adjacent surfaces of the pavement-like cells which would interfere with a sharp bending of the wall in the region which is to become the edge of the wing. As the wingpad collapsed during the hardening of the cuticle after the molt, there would therefore remain all around the edge of the wing an appreciable cavity. As soon as a cavity is produced between the two cell layers of the bag it acts as a blood sinus, putting the cells immediately adjacent to it in nearly the same relation to the food as the cells of the general body wall. This explains their subsequent secretory activity at the time of the production of the cuticle.

The marginal vein is often not of uniform size around the whole of the wing, being usually strongest on the front margin, often weak on the hind margin, and quite commonly entirely absent on the outer (distal) edge of the wing. This corresponds with the chances these parts have to secure nutrition from the blood. If the channel is not freely open all around the margin, so that all parts have a nearly equal chance, then the parts farthest from the body are much handicapped, and as between the front and hind margins the former has the advantage of taking its nutritive supply first.

It is conceivable that a vein arising in the way here described might in part disappear and afterwards reappear in the history of the group, corresponding to changes in body-form or order of development; indeed, that it would be very susceptible to such changes. This is in accord with the peculiarities of the occurrence of the vein, for it not only appears in widely divergent groups, but is subject to variations that are often of only generic significance.

A vein of much more fundamental importance, one that is invariably found in functional wings and usually the strongest vein present, I denominate the *primary*. Its position is normally within the anterior third of the wing, but in a few cases it may be farther back, as in the gill cover shown in Fig. 1 (page 12), where the anterior margin is strongly developed and the primary takes a position somewhat behind the middle for reasons of utility. Among true wings there is a modification in certain Phasmidæ, where the primary vein takes a posterior position, due to the exaggerated development of the anterior region for another purpose than flight.

The typical position is dependent on the same mechanical necessity that determines the position of the bones in the wings of a bird or bat, or the shaft in a feather. The ontogeny of this vein is associated with the development of the interpleural suture into an articular process; that is, the position of the basal end is determined by this association. Probably the course of the vein was originally determined by the fact that the longest axis is the weakest line and most liable to bend. The primary fold would thus be associated with the primary vein.

The basal attachments of this vein, its primary significance ontogenetically, and its functional importance in the wing, all conspire to cause it to take and maintain its preëminence when a complex venation is built up around it. No vein, unless it be the marginal, is as easily identified as the primary, and there is none in reference to which there is such a perfect unanimity of views among students of venation in the matter of its homology in the different groups. The many names it has received are simply due to differences in nomenclature, not to differences in interpretation of homologies.

If there is any vein that can be homologized throughout the whole class, it is the primary vein. This vein, then, must be the starting point in the study of homology, as it is the oldest, most important, least variable, and most easily recognizable vein of the wing membrane.

The primary vein is usually conceived of as a branching vein, though, of course, it must have been at first simple. Usually there are more branches of the primary vein than of any other vein in the wing. Sometimes they are given off from both sides of the vein, more commonly from only one side, which may be either in front or behind. The largest number is seen in cockroaches; the simple unbranched condition occurs in many groups. Between these two extremes there are all intermediate conditions. Perhaps the commonest number is four, making with the end of the vein itself five ends, the number supposed by several recent authors to be the typical condition.

Branches are given off usually at an angle of rather more than sixty degrees, and proceed outward ordinarily in a more or less evident curve, the concave side of which is toward the tip of the vein from which they arise. They are produced at

very regular intervals and lie parallel with each other, and sometimes, when long, come to take a position almost parallel with the primary vein.

For rather small wings, branches afford what is probably the most satisfactory mechanical solution of the problem of supporting the wing membrane. When the wing becomes larger, however, the torsion on the principal vein would begin to be a serious matter, so that other means of strengthening the wing become necessary.

The ontogeny of the vein branches is explainable on the supposition that the tendency toward multiplication instead of specialization of the cells of the wingpad when carried too far results in the production of transverse wrinkles, which open up courses for the food material in the vein to find its way outward. If this occurs before the specialization of the membrane cells has gone too far, it may result in the extension of the vein area in that direction. The course of a branch produced in this manner would be governed by the same forces that determined the course of the primary vein; that is, the vein branch would follow the lines of least resistance. This would be at first approximately at right angles to the primary vein, and as soon as it gets beyond the influence of this vein it would turn forward to reach the margin at approximately right angles. Sometimes branches occur that leave the primary in the way indicated, then turn forward and run parallel to it for a distance, and then turn again to meet the margin squarely. Such a vein follows both of the lines of mechanical weakness; that is, parallel to the vein and at right angles to it. Of course, veins do not bend abruptly, and the tendency is always to go straight, so there is always a compromise effected, which reduces the angle of branching considerably below ninety degrees.

An increase in the size of a wing usually results in an increase in the number of veins. There are many notable exceptions to the rule that the size and number of veins are correlated, but these only emphasize the general rule. In many of the lower insects the tendency of a wing to develop a vein wherever there is room is very evident. To this tendency we may look for the explanation of many of the facts relative to the perfection of the venation system of insect wings.

Two sets of veins early to be developed constitute the series which we may denominate *the anteriors* and *the posteriors.* These are independent series, being developed on separate sides of the primary vein, but they arose in exactly the same manner. These are the veins that radiate from the base and occupy the membrane not served by the branches of the primary. They would be produced in a series one after the other as the size of the wing increased, and may be numbered in the order of their development, which is from the primary outward. The stages of development are illustrated in the accompanying diagrams. (Fig. 23.) These anterior and posterior veins, as they are produced, will extend themselves across the membrane at its weakest points and thus divide the area more or less equally into two parts. Probably the first of these veins to be developed was the first posterior. The time of the appearance of the next posterior in reference to the first anterior can not be decided, as the two series have no necessary relation to each other. The anteriors and posteriors may become branched, but as they become successively closer together the probability of branching rapidly diminishes. The first posterior is often branched, but seldom as much so as the primary.

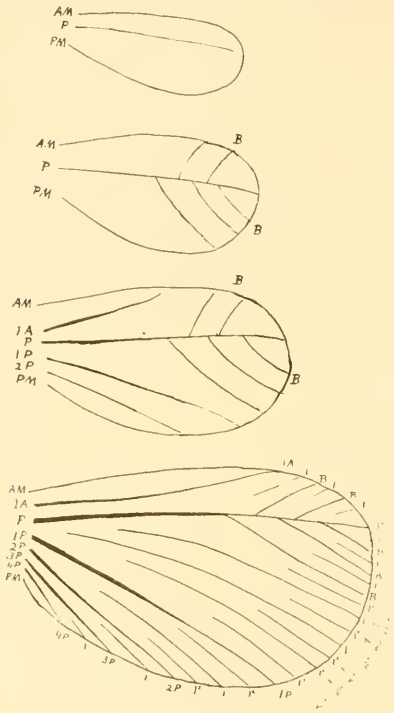

FIG. 23. Diagram illustrating proposed theory of the development of venations.

AM, anterior marginal vein; PM, posterior marginal vein; P, primary vein; B, branches; 1A, anterior vein; 1P, 2P, 3P, 4P, first, second, third and fourth posterior veins; 1, independent veins; 1^2, 1^3, and fractions $\frac{1}{2}$, $\frac{1}{4}$, $\frac{3}{4}$, etc., possible ways of designating independents.

All the veins so far considered have arisen directly or indirectly from the base of the wing. While they are hardly to be designated as outgrowths of the cells of the body wall, they are

nevertheless produced from cells that have developed under similar conditions. These conditions have progressed from the base of the wing toward its tip, so that these veins may fairly be regarded as outgrowing veins. They maintain their connection with the body cavity in the adult condition in the groups which, in this respect at least, we may consider to have retained the primitive condition; that is, the Odonata and Ephemerida. In all other existing groups of insects the base of the wing has been profoundly modified by the development of the structures that make the flexion of the wing possible.

The vein least affected by this specialization is the primary. Its relative strength is probably the reason that all the other veins of the wing gave way while the primary is merely made flexible, becoming the axis of flexion. The changes in the articulation of the wing thus brought about have already been discussed, and it has been shown that the only close attachment of the wing to the wing-roots is by the primary, though it may be assisted by an adjacent vein. This fact has given the primary vein still more importance in venation, but has somewhat complicated its study, because of the tendency of other veins to attach themselves to this one. The extent to which this occurs will be evident from a study of the modifications in the different groups.

Anterior to the primary vein the effect of flexion has been most marked in the specialization of the base of the marginal vein. This vein has been broken into a number of movable, hollow segments, separated from each other by areas of soft skin; a tendon terminating in a muscle passes through these segments to be attached to the distal elements of the series. Thus the insect is enabled to pull the distal element toward the base of the wing, the front edge of which is thereby drawn forward till the organ is expanded ready for action. Insects usually possess but a single anterior vein, which loses its basal connection, attaching itself to the primary and becoming weak except when it takes part with the primary in the articulation. This specialization of the marginal vein makes it necessary, if there is to be any considerable expansion of the wing anteriorly, that the membrane extend beyond the vein; that is, that the vein no longer lie along the margin. When this occurs and the vein extends any considerable distance, the membrane so produced is served by branches on the outside of the anterior

marginal vein. This condition is not common; it is best seen in the front wing of the cockroach.

Behind the primary vein all the veins except the marginal lose their basal connections. The marginal vein is so delicate at the extreme base that it is generally overlooked, and because of its weakness it offered no obstacle to flexion, and so escaped the fate of all posterior veins. Practically the whole difficulty in homologizing veins arises from the difficulty in identifying these posterior veins. How great these difficulties are, and how completely we can follow these vagrant posterior veins, will be shown as we discuss the different groups.

This brings us to the consideration of a class of veins that never has had basal connections. These we may denominate the *independent veins.* The term "independent" has already been used in Lepidoptera for these veins, and has never been used in any other sense. The independents are most uniformly present in the area immediately behind the primary vein, and have here been designated by Comstock and others as the "media." Exactly similar veins may occur between any two veins and develop in the same manner. These veins may be designated by the vein immediately anterior to them.

The independents arise from the *margin of the wing*, and might possibly be considered as ingrowing branches of the outer portion of the marginal vein; but, since this portion of the marginal vein is commonly absent, while the independents are almost always present, this conclusion may seem to be unwarranted. In insects rich in independent veins, these are produced wherever there is a sufficient space between two veins, and they extend up the wing as far as the space remains sufficiently wide. The order of their development in any space (compare Fig. 23) is, first, the production of a vein approximately half way between the two veins bounding the area; secondly, one on either side of the first independent vein, and then one in each of the four interspaces thus produced. This process might go on indefinitely, but generally three or four ranks of veins are all that can be clearly recognized, except in Ephemeridæ, where this system is most highly developed.

The relation of independent veins to branches is such that it has given rise to confusion in the study of homology. In the most typical condition the independent veins are strongest

at the margin and become weaker as they proceed inwardly (proximally), the ending being similar to that of the outgrowing veins, but in the opposite direction. In some cases, however, they have gained an attachment to an outgrowing vein through a cross vein, becoming so completely united to it that they have all the characteristics of branches. There is nothing in the structural peculiarities to determine whether a particular vein arose as a branch or as an independent vein; the only criterion being a comparison with the venation of other members of the same group, the principle being to class as an independent vein anything that anywhere exhibits structures characteristic of independent veins. It is not certain that branches in the strictest sense may not, under some circumstances, especially that of their relation to a cross vein, take on some of these characteristics. Such appears to be the belief of several recent students of venation, who, having adopted a typical number of branches as belonging to the vein we have called the primary, include among them in many instances veins which show very evident signs of their independent nature. I am convinced that there is no reason why, in any group, branches might not be decreased or increased in this way to any extent, and that the application of the typical-number hypothesis can not be depended on as conclusive evidence of the nature of a supposed branch. At the same time, while there is a theoretical typical number of independents in any area—that is, one, three, seven, fifteen, etc.—a very little inspection of venations will convince one that the typical number is rarely attained. The reason is that an independent vein only approximates the middle of an interspace, so that a vein in the next series will commonly be quicker to develop on one side than on the other, and this difference may become more and more exaggerated as time goes on. In some groups the evidence may be so plain that there can be but little doubt as to the source of the vein appearing as a branch; but whether we can homologize and clearly distinguish between true branches and independent veins throughout the whole class, is open to doubt.

A matter which somewhat complicates the question of independent veins is that specialization of the wing membrane which results in what have been called convex and concave veins. There has been no satisfactory explanation of the cause

of these bendings of the membrane, beyond the bare suggestion that this condition is useful in stiffening the membrane. The explanation of Adolph, that they represent fundamentally distinct elements, has been shown to be without foundation. The method of development of these convex and concave veins appears to be as follows: If one examines an insect wing, such as that of a butterfly, he will notice that the wing membrane between the veins passes from vein to vein in a gentle curve the concavity of which is dorsal. The reason for this may be that, since the hardest stroke is downward, a convexity in this direction is useful to stiffen the wing. One can readily see that such a curvature would have this effect, since the flattening of each arched area by the resistance of the air would force the veins apart and thus render the wing more tense. If between a marginal vein and the primary an intermediate vein were developed in such a concavity it would be a "concave" vein. After a vein was produced in such a concavity and became strong the membrane would no longer make a single curve, but the portions of the membrane on the two sides of the new vein, would become independent of each other and respond to the influences that cause the curving of the membrane in the first instance, both portions becoming concave above, so that upon the development of new veins it would in time become a "convex" one. According to this theory, then, a concave vein is merely a young vein, and a convex vein an older one. Thus if there was but a single independent in an interspace it would be concave; and if there were three, the center one, which was the first one developed, would be convex and the other two, one on either side, concave.

In cases where the veins are very numerous and their alternate convexity and concavity is very pronounced, this rule is varied in such a manner that no well-established vein changes its position either to concave or convex on the production of intermediate veins. The membrane in such a case has the form of a compound or S-shaped curve (Fig. 24, C 7), being in part concave, in part convex. In this membrane the independent vein starts, as elsewhere, with first a single vein and then a smaller one on either side. The middle vein (Fig. 24 B 4 or 5) and the most precocious of the two lateral veins (C 6 or 8) soon adjust themselves respectively to either the highest and lowest (C 4 and 6) or to the lowest and highest

(C 5 and 8) lines along the membrane and soon greatly outstrip the third vein (C 7 or 9), which may then become a middle vein in the next developing set. In groups possessing this type of vein structure, as the mayflies, the independents are thus developed in pairs, one convex and one concave, the latter being the one next to the convex vein in the interspace.

The cross veins resemble the independents in some particulars, but differ from all other veins in that they have no determinable sequence in their first production. It is probable that they were developed over all parts of the wing at the same time. Like the independents, they probably correspond to wrinkles in the membrane, but not to wrinkles parallel to the principal veins. Cross veins do not always correspond in structure with longitudinal veins, though at times indistinguishable from them. Like the independents, they are often not clearly distinguishable from branches. The usual practice is to class a cross vein as a branch, if in any species of the group the vein in question exhibits a position resembling that of a branch. This interpretation is probably in most cases correct, though in considering the relation between independent veins and branches the opposite method is pursued; that is, if there is any evidence of the vein in question being unattached, the interpretation is usually that it is an independent vein.

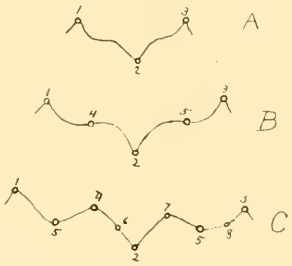

FIG. 24. Diagram illustrating the development of independent veins without disturbing position of older veins.

A, B, C, three successive stages; 1, 2, 3, older veins; 4, 5, those first interpolated; 6, 7, 8, later additions, of which 6 and 8 remain feeble.

In most wings with few cross veins one may see the whole membrane, if held in the right light, wrinkled in a very regular manner, suggesting a regular system of cross veins. In order to transform a simple venation into a netted one, it is only necessary to assume that the tendency that brought about the wrinkling corresponding to the longitudinal veins was carried a step farther, so as to open passageways for the blood from vein to vein along the course of the transverse wrinkles and then, in the same way that we have supposed the branches developed—or for that matter the principal veins themselves—the resulting change in the nutrition of the cells

bordering these passages would secure a greater chitin-producing power.

The evidence of such simultaneous production of cross veins all over the wing is that in all the oldest venations these veins are most inconstant in both number and position, none seeming to have any preëminence or to show any significant peculiarities. There is, however, a difference between those near the body and those near the edge of the wing, the latter being much closer together, and correspondingly more delicate. In all these points the cross veins resemble the wrinkles, and prove that the cause of their production must have been something that influenced the wing as a whole. If the cross veins had different origin, or method, or time of development, we should not expect such a degree of uniformity. Among higher insects certain of the cross veins exhibit characteristics that mark them off as distinct from the ordinary cross vein, but in most of these cases the number of cross veins has certainly been reduced from a condition in which they were more abundant. These special cross veins, then, are probably later specializations.

By way of *résumé*, we may say that, in place of the earlier arbitrary schemes of venation, or of those that were based on the assumption that the veins represent the remains of an ancient tracheal system, or of the ingenious but unsupported theory of Adolph, we would substitute a new theory of venation—a mechanical theory. According to this theory the utility of the veins in flight is the prime factor determining their number, position, and character. Several distinct classes of veins are recognizable, not structurally, but on account of their place or manner of origin. The marginal vein, which arose by a modification of the cells at the bend in the wing-pad, is always present next to the base of the wing on both margins, but often disappears along the outer edge of the wing, and occasionally may come to lie at a distance from the edge. The primary vein is clearly the most important vein in the wing, because of its relation to the pleural articulation and later to flexion. In this development the branches, like the primary itself or any other vein, follow the lines of least resistance in the membrane, and have very definite relations to the trunk vein. The anterior and the posterior veins are developed to meet the increase of the wing surface, and approx-

imately bisect the areas in which they develop. The basal attachment of these veins has been destroyed in wings that are flexed, and this often gives rise to much uncertainty as regards homologies in distant groups. Veins of another series arise independently between the tips of these and grow toward the base, often becoming attached and thus simulating branches. Veins are shown to have a very definite relation to the plane of the membrane, some being above (dorsal), others below (ventral) that plane. Thus we have the so-called convex and concave veins; when the alternation of these veins is well established the independent veins are produced in pairs between them. Somewhat allied to the independents in the method of their formation are the cross veins, which are believed, however, to have developed simultaneously over the whole wing surface and later to have undergone specialization, accompanied by a decrease in number.

METHODS OF MODIFICATION.

Having traced the development of these systems of veins that give character and stability to the wing, there now remains the necessity of following the organ along the lines of modification which have resulted in the production of the various types of venation that exist in the different groups of insects.

In these diverse specializations, while each has followed a course in certain respects peculiar to itself, they have all been controlled by common limitations. Some of the more important of these common methods of modification should be considered before proceeding to the detailed review of the special types of venation.

A factor constantly influencing venation in an insect wing is the coördination of the front and hind pairs. Whatever the solution arrived at in any particular case, the venation can be confidently expected to offer evidences of the reaction of these organs upon each other.

The original condition was doubtless one in which the wings were entirely independent of each other, such as exists to-day in some of the dragonflies. The only requirement in these cases is that the wings shall not interfere with each other. As a consequence these insects have long and slender wings, and the most conspicuous difference to be observed in their

venation is the arrested development of the veins of the posterior region of the front wing as compared with the hind wing when the latter has become somewhat expanded.

The coördination of the two wings permits more variation in shape than in non-coördinated wings. We find, therefore, in these wings, much greater range of variation in venation. Coördinated wings are not usually of the same size. When the front wing is the larger, it is always longer than the hind wing; but when the hind wing exceeds in area the front wing, the difference is wholly in their greater width, except in certain beetles and cockroaches. In making this generalization we are considering only cases where both wings are functional as organs of flight.

The simplest method of coördination is produced by the development of the adjacent edges so that they overlap each other, the hind wing always lying beneath the front wing. The other method consists in the specialization of structures on both wings, by which these organs are held firmly together. When wings are bound together they act as a single wing, and the mechanical needs of the different areas have but little in common between corresponding parts of the two wings. This gives ample reason for the differences that have been brought about.

The rule is that, if there is any difference in the number of veins in the anterior or posterior areas, the lesser number will occur in the posterior region of the front wing or in the anterior region of the hind wing. A simple and very striking illustration of this may be seen in the wings of the honey-bee (Fig. 92).

There is always a certain amount of disturbance of the venation in the region where the connecting structures are developed. Both the character and the position of the veins may be modified in this region. The attachment may be accomplished by means of a groove, produced by the folding over ventrad of a portion of the hind edge of the front wing to the extent of 180 degrees, and the development, on the adjacent part of the hind wing, of a series of hairs, much enlarged and specially modified into hooks which fit into the groove above. This is the structure in the Hymenoptera. Another modification, occurring in *Cicada* and related insects, differs in having a portion of the front edge of the hind wing bent upward into a hook locking

into a corresponding hook of the front wing. A third method, seen in such Heteroptera as *Belostoma*, consists of a pair of projecting processes on the under side of the front wing near its hind edge. These are of such shape and position that they clasp around a thickened portion of the costal vein of the hind wing. A similar method obtains in the Psocidæ, but in some instances in this group the normal structure is supplemented or replaced by the clasp shown in Fig. 18.

In the Lepidoptera a rather less efficient structure with the same purpose is the frenulum. See Comstock ('93), Kellogg ('95). In this group the coördination was probably at first dependent on the overlapping of the wings. With the primitive forms the wings were probably not particularly wide, so that their overlapping involved a great loss of effective surface. The development of the frenulum, which prevents the wings being pulled too far apart, allows the reduction of the overlap to a minimum.

In any case the effect of coördination is to be seen in the straightening of the adjacent edges of the wings, and a tendency toward reduction in the number of veins of the adjacent wing areas. In addition to this, there is the local specialization of the coördinating organ.

Another entirely distinct form of coördination is that which exists between the two front wings in the Coleoptera and Hemiptera. In both orders the coördination is brought about to make the organ more efficient as a protection for the hind wings when at rest, rather than to aid in flight. As the result of this specialization in the Coleoptera the marginal vein of the hind edge of the elytron becomes much enlarged and peculiarly modified to form a catch, by means of which the two elytra are held firmly together when at rest, the edge of the wing at the same time having been so straightened that it exactly meets the corresponding edge of the other wing throughout most of its length.

In the Heteroptera the marginal vein is also strongly developed, but not brought into such intimate relation to the opposite wing. The most characteristic matter in this coördination is the structure of the apical third of the wing. This region is so shaped that when at rest it exactly overlaps in the two wings. As a consequence of this duplication there is not the need of as much thickening of the membrane in this

region, and the wing remains a more efficient organ for flight. Also as a consequence the venation in this region does not become obliterated to the extent that it does in the basal region. The cross veins along the basal edge of the membranous portion of the wing have become specialized into a strong transverse vein, from which in many cases all the other veins seem to arise, because of the obliteration of their basal connections.

The coördination of the wing with various parts of the body is, like the last, a development to accommodate the wing when at rest. Either edge may be involved, or the coördination may show itself in changes on the disk of the wing. It is always the front wing that is modified. The front edge is sometimes made to conform to the shape of the body so that it will fit closely. Generally the body is modified at the same time, the adjustment being mutual. In many beetles and in a few Hemiptera there is a special provision for holding the wing against the body; but none of these adjustments greatly affect the venation, except locally. The hind edge modifications are of a similar sort, and are equally barren of great results upon the venation.

The modifications that occur on the disk of the wing consist of a fold, usually quite abrupt, whereby the wing brings itself into general conformity with the shape of the body. This fold usually occurs just in front of the first posterior vein, and when present divides the wing sharply at that point into two regions. Commonly the line of fold is bordered on either side by a strong vein, and is not crossed by cross veins, but only by the marginal vein at the end. This fold has been usually identified with a line found in many insects where no actual fold occurs, and with the first folding line of the hind wings. All of these lines can not be considered homologous, however, as will be brought out in the discussion of the venation of the different groups. Where the fold occurs in the front wing it certainly influences very profoundly the adjacent venation.

The modification of the hind wing that most nearly corresponds to this front-wing fold is the system of folds whereby the wing is made to occupy as little space as possible when at rest, so that it will be protected by the front wing. The fold in these wings is always a full 180 degrees. so that the folded wing lies flat. All wings, except those of the Odonata

and Ephemerida, have a flexible area at the base behind, which, if of considerable size, may contain one or more veins. Very commonly there is more than one fold, in which case all possess veins, except it be the basal one. The number of folds may become very large when there is much disparity between the size of the two pairs of wings, as in many Orthoptera. In most beetles, in earwigs, and in some cockroaches the folds of the hind wings lie in various directions in addition to those radiating from the base, which we have just been considering. The effect in all of these cases is the almost complete isolation of each area bounded by folds. The fold thus produces a profound effect upon venation.

There are two distinct influences produced by folding. One of these is the severance of the veins, already alluded to, and the other is the production of new veins to define more sharply the line of folding, as well as for the stiffening of the folded area. These will be discussed in more detail when considering the groups affected.

One of the two methods of specialization recognized by Comstock and Needham in the production of types of venation is the addition of veins. Adolph considers the maximum number the primitive condition, so that all specialization involves reduction. According to the theory of venation offered in this paper, all venations may be considered to have been produced by addition in the first instance, though in most cases a subsequent reduction takes place. The theory provides for indefinite increase or decrease along what may be called normal lines; that is, by the duplication either of posterior veins, of branches of existing veins, of independent veins, or of cross veins, or by the suppression of these same veins in the reverse order. This process can hardly be called specialization, however, but rather simply normal increase or decrease. Specialization is an unusual process producing unusual results. A dragonfly possesses a specialized venation with many veins, and a Psocid one with few veins; but it can hardly be said that in the one case the securing of the many veins, or in the other the loss of them, was the means whereby their peculiarities were brought about.

A true specialization by addition occurs in insects with folded wings, where veins are produced in a manner quite different from the normal orderly manner in which new veins are

produced. In other cases where numerous veins occur, the specialization is one that has fixed the many-veined condition.

Specialization by reduction is a common phenomenon; without doubt much of the reduction that has occurred is produced by normal decrease, but in most cases part of the reduction has been brought about through specialization. The specialization of cross veins is always a reduction process. Whenever any cross vein becomes strengthened it decreases the chances for survival of the adjacent cross veins. The cross veins were produced simultaneously over the whole wing, and the natural tendency would be for them to disappear in the same way whenever the conditions ceased to be favorable for their production. Those to survive would be the ones specialized through some special association with the longitudinal veins.

There are at least four ways in which a cross vein may come into this unusual relationship: It may so lie as to bring the end of an independent into close connection with it, and so become, to some extent, the continuation of the independent vein; it may lie exactly opposite another cross vein as though the cross vein were continuous over the longitudinal vein; it may come to lie in a position parallel with the margin and be favored more on account of the weakness of the membrane in this region; or, finally, it may gain its preëminence over neighboring cross veins by binding the longitudinal veins together at critical points.

In regard to the first of these methods, it may be remarked that the connection of the independents to the outgrowing veins, making them take on all the appearance of branches, is an extremely common occurrence. An independent vein naturally follows a furrow, and a cross vein has the same peculiarity. When the longitudinal furrow of the membrane begins to disappear through the approximation of the adjacent veins, it would not be unnatural to expect that the vein would have a tendency to turn aside, if a transverse furrow were at hand. Thus, the cross vein lying here would be augmented by the tip of the independent and make such a large opening into the adjacent vein that the cross vein and independent vein together would resemble a branch of the stronger vein.

The development of cross veins exactly opposite one another is a very common occurrence in wings. Their usual place of development is across a vein that lies mainly on one side of

the membrane. If one side of the wing in the vein region does not take part in the formation of a longitudinal vein, it is not difficult for a cross vein to extend its influence across to the other side. Not uncommonly, where the longitudinal vein is very much to one side, the cross veins actually establish a connection across from side to side. The vein thus formed across the longitudinal vein sometimes becomes quite strong and important. An extreme case of this sort has been described in this paper in the triangular cross vein at the base of the wing of *Eschna*. (See page 31.)

The advantages a series of cross veins would have, in case they came to lie parallel to the margin, is evidently the explanation of the veins of this nature that are so common in the wings of certain neuropterous insects. The combined cross veins in this case come to bear the same relation to the outer margin that the primary vein originally had to the front margin. It is doubtless only another expression of the power that tends to hold all the longitudinal veins parallel with one another. Sometimes there will be more than one line of cross veins parallel with the margin. The cross veins on the disk of the wing that sometimes extend as a series of continuous veins at right angles to the longitudinal veins, are certainly related structures, though they have no relationship with the margin.

What gives the cross veins that follow the margin their high development and permanency is the fact that they connect veins which reach the margin more or less obliquely. The influence of these cross veins causes the elements of the longitudinal ones to alternate with each other while the cross veins become continuous and prominent. The cross veins become coördinated in spite of the tendency impressed on them by the longitudinal veins—they become stronger, and then the logitudinals conform to them in the same way they would to a marginal vein.

The space between the primary and the first posterior vein is larger than any other interspace in the wing—usually nearly or quite a third of the whole wing area. The consequent weakness of this region is not wholly relieved by the insertion of the independents. Here, then, is a place where a series of coördinated cross veins serving as a connective between these two veins would be of particular utility. Sometimes the veins are not coördinated, but are equally important

as connectives. If the independents are strong, and especially if they are joined together basally, the necessity of the connective cross veins being coördinated is by no means as evident. On the other hand, if the cross veins are coördinated and strong, there is no need of the independents extending inwardly from the connecting cross vein, and they may be entirely suppressed.

There is a similar reason for the strengthening of the cross veins into connectives to bind the primary to the front margin, or to connect the first and second posteriors. The connective between the primary and the front margin is of particular importance, and is found in some form in the majority of insects. This connective may not be so useful in directly preserving the stiffness of the wing as it is for bearing much of the strain consequent on the pull of the muscle that expands the wing.

A matter that has a great influence on venation is the uneven increase or decrease of wing areas. This subject has never been adequately discussed, nor have I sufficient data at hand to treat it in detail, and so can consider only the most evident facts. The best evidence on this subject is that afforded by the study of the front and hind wings of the same insect, because we do not have to consider here the question of difference in type. Likewise, preference should be given to wings that are as near alike in general appearance as may be. A very good type with simple venation for this study is that of the Aphidæ, and a more complex one is that of the Hymenoptera. In both of these cases there is a much simpler venation in the hind wing than in the front, a difference not wholly explainable on the theory of the reduced size, but apparently largely a matter of difference in shape brought about by a change in the apical part of the wing.

In cases of this kind I think it is safe to assume that increase in a wing area would do just the same things that a decrease would undo. Where there is difference in size we need not inquire whether one or both of these processes were in operation. In the cases suggested above we may suppose, to judge by the number of veins in the most nearly related forms, that the front wings are examples of increase and the hind wings of decrease.

The most evident fact brought out by an examination of these wings (see Figs. 63 and 80) is, that the modification is

almost, or quite, confined to the area increased or diminished. Thus, if the two pairs of wings in an aphid were cut across just before they begin to become narrower toward the tip, they would have an almost identical venation. In Hymenoptera the front wing somewhat overhangs the hind wing. If the front wing is cut across just before the beginning of this extension and the hind wing also at the corresponding point as indicated by the end of the first posterior vein, the venation of the resulting basal portions will agree very closely in their median area. The difference associated with the coördination, since it affects the anterior and posterior areas only, constitutes about all the difference there is.

In a like manner the Psyllidæ, the Psocidæ, and other groups show the truth of this general contention. The independence of the different areas of the wings is further borne out by the development of the system of plication veins in many of the Elytroptera, as will be described when treating of those groups.

There are three distinct regions of increase or decrease in an insect's wing: the anterior, outer, and posterior margins. The central area can be but little affected according to this law of the independence of regions. Each of the three regions is subject to different methods of vein increase or decrease.

The anterior margin is limited at the base by the marginal vein, which has become essential to the wing because of its function of holding the wing spread. There can be, therefore, little or no addition of veins at the base, though the margin of the wing does sometimes extend out beyond the vein that originally bounded it. The amount of increase of this area is distinctly limited by the flight requirements, which hold the primary near the front edge of the wing. In the cases where the wing serves some other purpose than flight, as in certain Phasmidæ, this area may have enormous extension. The added veins of this region always partake of the nature of branches, though probably originating as independents, or possibly in some cases as cross veins. Whatever their origin, they are soon indistinguishable from true branches.

The diminution of added veins in the anterior region appears to take place mostly from the base outwardly, but this is a matter very difficult to decide. The subject is one capable of experimental study by decreasing by breeding methods the size of insects that are subject to considerable variation in nature.

My own investigations have not gone far enough to show more than this tentative conclusion. Still further decrease consists in the suppression of the ends of the longitudinal veins. Either the marginal vein may disappear, all except the extreme base, as in many Lepidoptera, where the anterior vein has become very important by taking part in the articulation; or the anterior may weaken and fade out, as in Diptera, in which case the marginal remains strong and only disappears by fusing with the primary, the two melting together more and more till only the bases are separate.

The outer margin may increase by elongation, or, by a broadening, probably in all cases by growth in both of these directions, though in different relative degrees. There is no limit to the amount of extension, except the mechanical one due to the necessity of support by the basal parts. If the extension is chiefly longitudinal, the primary and the independents are simply extended and strengthened and the latter increased in number. If the extension is very great, they assume an oblique position. On the other hand, if the extension is largely across the diameter of the wing, making a triangular wing, the effect is greatly to increase the independents, as in the Ephemeridæ, to strikingly change their course, as in the Psocidæ and Aphidæ, or to favor the holding of a considerable number of cross veins, as in the Hymenoptera. The latter tendency we can consider the normal course, as in the Ephemeridæ there is as much increase in length as in breadth, and in the other cases the small size of the wings prevents the natural tendency from showing itself. The peculiarities of the reduced wings in Hymenoptera indicate that in general the diminution is by the suppression first of these cross veins, and then of the longitudinals.

The hind margin is expanded in the hind wing much more commonly than in the front wing, though there are some cases where evidence of this specialization may also be seen in the front wing. Usually the front wing shows evident reduction. The method of increase of veins is usually by the production of additional posterior veins, and if there is a tendency in the wings toward the production of numerous independent veins, there may be one or more in each interspace. The characteristic thing about this area, however, is the duplication of the posteriors. This area can not be very greatly expanded with-

out the developing of folds. The extreme specialization in this direction is seen in the Orthoptera, where the number of posteriors has become very large.

The process of decrease appears to follow two lines: The posteriors may fade out and disappear from the hind angle forward, in the reverse order to their production. The other method is seen in the cases where the bases of the veins have been modified into an arch-like structure to hold the base of the wing flat when lying at rest upon the body. In this case the tips of the veins fuse together, and this fusion extends more and more toward the base till the two veins ultimately entirely coalesce. In the front wings of Lepidoptera the posteriors very commonly show evidence of this fusion. In several families of Diptera the first stages in the process can often be seen all around the outer edge of the wing, and the method of the fusion of the marginal to the primary is the same process.

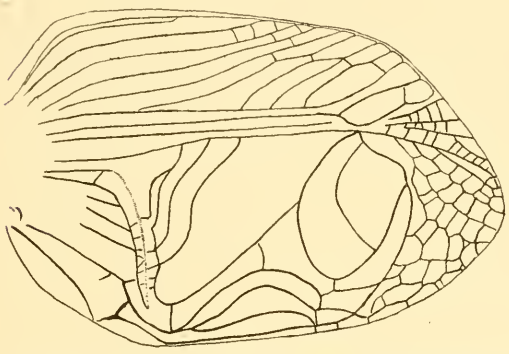

FIG. 25. Front wing of male cricket (*Gryllus*), showing expansion of posterior region to form a sounding-board for stridulating organ.

In contrast with these evidences of the independence of areas, we may find abundant examples of modifications of one area which greatly change the size and venation. We will call attention to only one of the most striking cases of this kind. In the accompanying illustration of the front wing of a male cricket (Fig. 25) we may note the great expansion of the posterior area for the production of the stridulating organ, which so impinges upon the space usually occupied by the principal series of independents that the area has practically disappeared, except at the extreme tip. Modifications of this kind are evidently not for flight, and need not be considered in detail.

Résumé.—Among the methods of modification of the simple type of venation, those dependent upon the coördination of the two pairs, as we have seen, involve various special modifications of the immediately adjacent parts, as well as a general adjustment of the whole wing areas. The coördination to parts of the body is of another kind, appertaining to the wing at rest rather than in flight, and so is best seen in wings modified as elytra. In the hind wing the arrangements for folding are dependent upon this elytral modification of the front wing. There is a normal method of increase or decrease of veins, which does not result in any particular specialization. The reduction in the number of the cross veins is usually true specialization, because it is not usually a process involving the whole wing, unless it be associated with decrease in size. The surviving cross veins may owe their preservation to their becoming continuous with longitudinal veins, or with each other.

PART III.—TYPES OF VENATION.

In the discussion of the types of venation we shall, for convenience, group insects into three series, which may be designated the Neuroptera, Elytroptera, and Neoptera. These are not offered as natural groups, but merely convenient assemblages of groups from a pterological point of view.

NEUROPTERA.

Neuroptera is used in the Linnæan sense, but includes all the older fossil forms that have been assembled under the name Palæodictyoptera by Scudder, thus representing the primitive winged insects and all the derived groups excepting the three with the thickened front wings and the three most recently evolved orders.

The two problems that present themselves most prominently to the student in this group are, first, the treatment to be accorded to ancient venations, and secondly, the criteria for the recognition of the separation of distinct types.

ANCIENT VENATIONS.

The study of venation is nearly coextensive with that of the classification of insects. Not only is the venation correlated with the systematic position of an insect, but all the problems involved in the grouping of organisms apply with equal force to the interpretation of the specialization of such an organ as a wing.

The venation of the most ancient fossil remains of insects has not thus far yielded as satisfactory evidence on the early course of the evolution of venation as it has been expected to give. For this reason it has not figured very conspicuously in the discussions of venation. Before the close of the Paleozoic era, insects were evidently already abundant and varied in form. The remains preserved to us in the rocks are everywhere acknowledged to be extremely fragmentary, and the relation of these ancient forms to the existing groups is a matter of controversy.

One of the many fundamental points upon which there is a conspicuous absence of agreement is the question of the division line between groups. In the taxonomy of existing organisms the question is of less practical significance than in paleontology, or in the study of phylogeny. The view that in nature there are really no division lines is a statement of a fact that, though true, is an evasion of, rather than an answer to, the question, for as long as there are real differences in nature, there are real divisions, though neither of these be absolute.

These divisions are by no means to be interpreted as indicating absolutely isolated, unapproachable structural types, but do signify diverse lines of evolution. All organisms would probably be proven to have a single common ancestor, if the course of the phylogeny of each group could be traced back to the beginning, and probably one would not have to go back to the very beginning of organic life to reach the individual from which all existing organic groups have originated. Likewise, in any group, as insects, the immediate descendants of the first representative of that group probably do not represent the separation of the ancestors of the two oldest orders. When this first division did occur, it is conceivable, indeed probable, that these two ancestral individuals did not differ as much from each other as they did from other forms then existing. A study of insects of that time would hardly have suggested the grouping that the descendants of those insects have revealed in their subsequent development.

For this very reason a study of Silurian or Devonian insects without a knowledge of the insects of later times, if such a thing were possible, would quite likely result in an entirely different system of arrangement from that which we use at the present day for existing insects.

Scudder's classification of the Paleozoic insects is the nearest approach to a system of this sort. His Palæodictyoptera brings together in one order a number of forms which had already differentiated to an extent sufficient to make them recognizable as the probable ancestors of different orders. Because of their evident similarity to each other, and difference from the existing members of the orders toward which they point, they are considered as not yet belonging to those orders.

Brauer ('86), on the other hand, would place the ancient

types directly in the groups toward which they are developing, and deny to them the status of transitional forms not yet sufficiently differentiated to be separated one from the other.

No one will seriously deny the contention that any really natural system of classification must be one that is natural at every stage of phylogenetic development from the earliest time to the present, and that it is proper to shut one's eyes to the later developments when treating the earliest forms. With equal truth it can be maintained that groups represent the product of two factors working in their evolution, of which one consists of those forces or conditions accountable for divergence in structure, and the other of those natural conditions making intermediate forms untenable. The greater groups are those separated by wide, impassable gulfs, and the lesser by narrower but none the less impassable gulfs. As soon as species are distinct, that is, as soon as interbreeding is impossible, they become as truly isolated as though the differences were of a more profound character. Classification therefore represents not so much the construction of a genealogical tree as the expression of the natural barriers which set the bounds to morphological differentiation.

According to the present practice of nomenclature we have to recognize in the primitive winged insect, for instance, a species, genus, family and order. Its first differentiation that became distinct would be a new species within the same genus, family and order. A new species would be considered as established as soon as a form became infertile or incapable of breeding with other forms of the original species. The total amount of divergence from the original form has no necessary relation to the question, the whole matter being dependent upon those items of differentiation which influence or affect the fertility or capacity for interbreeding.

For this reason it is evident that the whole species may develop away from the original type to any extent and remain one species, though not necessarily the same species as the primitive one. It may also vary to an extreme degree, but as long as the fertility between the individuals remains there is but a single species. Such extreme variation may either produce an inconstant polymorphism, or may be associated with changing external conditions, the insect becoming sensitive to them, producing phytophagic forms, seasonal variation, or alterna-

tion of generation, or may become associated with sex, producing the so-called secondary sexual characters, together with sexual dimorphism and such phenomena. Differences much less than these, if they are such as to prevent crossing, are sufficient to differentiate species.

In the formation of higher groups, while there is no similar criterion of separation such as that which decides the difference between species, there is the same independence of the amount of divergence between the members of the group, and the division is determined solely by the extent of the gap separating the group from its neighbors. No matter what may have been the theory of systematists, it has been the uniform practice in every department of biology to ignore the question of phylogeny in the limitations of groups of all ranks, and base them wholly upon the degrees of separation recognizable.

In the arrangement of the groups thus obtained the attempt is usually made, with greater or less consistency by modern naturalists, to indicate the lines or times of their development.

Applying these doctrines to the subject of venation, we must conceive that the first condition of the wing was one in which we could recognize but a single type of structure—one subject to considerable variation. Among these variations would exist forms suggesting types that later became separated. Every type of venation now existing is historically connected by regular gradations with the primitive form. If all of these intermediate forms existed at the present day we should have to deal with an organ whose variation was great, but at the same time of little significance. Only the fact of the isolation of groups by the suppression of intermediate conditions gives the variation taxonomic value.

With structures, as with species, there are thus two problems for study that should not be confused. One is the delimitation of groups, and the other is the phylogeny of these groups. There appears to be much reason for Scudder's Palæodictyoptera. Certainly, as far as the venation is concerned, there was not in the Paleozoic time sufficient differentiation between the various types of venation to consider them comparable with the divisions between orders at the present day. We may consider that at the close of the Paleozoic era there was only a single order of winged insects, though the name Neuroptera seems preferable to Palæodictyoptera. At the same time the phyletic lines of

several of our existing orders were certainly very definitely established. These lines of development lead to the present orders Odonata, Ephemerida, Corrodentia, Orthoptera, and Hemiptera. Those that prefer to consider these orders already established will thus recognize six orders of winged insects as existing at that period.

We will now consider in order the ancient types of venation that have been preserved to us, and the related modern groups, where these can be recognized. From the nature of the case one can not speak with as great confidence in regard to fossil forms as in regard to living, but even fragmentary data are of great value in tracing homologies. The classifications of fossil insects of the Paleozoic era given us by Scudder and by Brongniart scarcely resemble each other in any particular, but figures of the fossils classified by these two authors seem to indicate that, to a great extent, this difference was justified and that we may almost add the two systems together without doing violence to either.

MEGASCOPTERIDÆ.

This is the first of the ancient groups of insects in which there appeared evidence of a tendency to suppress the cross veins and still preserve a comparatively small number of longitudinal veins. The group is quite sharply defined from other known insects, and is supposed to represent an extinct branch peculiar to the Paleozoic era.

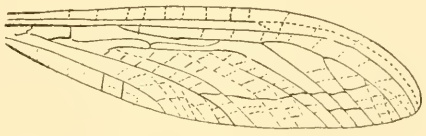

FIG. 26. Diagram illustrating the venation of the Megascopteridæ. Dotted lines indicate veins that may be present or not. Brackets indicate variable place of attachment of veins.

As will be seen by the accompanying figure (Fig. 26), the venation is distinctly of a neutral primitive type, which it might be possible so to adjust as to resemble either one of a number of venation types. In the shape of the wings, in the number and arrangement of the veins, and in the peculiarity exhibited by a number of the independents in changing their attachments, this wing agrees with the Termitidæ; but the really characteristic things about the venation of the Termitidæ are not suggested in these wings, and there is little or

nothing in the other parts of the body to suggest such a relationship.

Some members of the family possess a venation that could be compared rather closely with that of *Cicada*, but here, likewise, there is the entire absence of all the characteristics of a wing of that group, and the body characters show that here there is still less ground for comparison.

There is a very evident tendency to specialize one or two rows of cross veins parallel with the hind margin of the wing. The same tendency is seen to some extent in the Sialidæ and very distinctly in the Hemerobidæ. The Sialidæ is a comparatively undifferentiated group, so that its venation is not very distinct from that of the Megascopteridæ, but there are some characters which will at once separate them. The Megascopteridæ have a rather more consistent venation than the Sialidæ, and in the specializations of the cross veins are also distinctly in advance of that group. As to the Hemerobidæ, it is much easier to homologize their venation with the Sialidæ than with these insects. We must therefore concur in the separation of the Megascopteridæ from all the existing groups.

Their real relationship I conceive to be with the Odonata, Protodonata, and Ephemeridæ. All the fossil remains we have of these insects show them with their wings spread, and the appearance of the base of the wings would indicate that they were not provided with means of folding. The structure of the notum of the thorax, moreover, as far as it can be made out, lends further support to this idea.

If this supposition is correct, the Megascopteridæ and Protodonata represent two extremes in the development of this primitive type, for there is little similarity between the two groups. A group, doubtless derived from the latter family, has in later time gone through a process of reduction, in which the cross veins suffered to quite as great an extent as occurred in the Megascopteridæ, and produced the *Agrion* of the present day. In all respects *Agrion* is much in advance of the ancient Megascopteridæ.

PROTODONATA.

There can be no doubt of the correct identification of the insect remains that have been placed in this group as being allies of the Odonata. The wings possess neither stigma, nodus, nodal sector, arculus, nor triangle. But this list of

characters embraces all of the conspicuous marks of the wings of Odonata. However, with all of these wanting, the whole facies of the wing is so distinctly like that of the Odonata, that one would not hesitate to place it in that group.

The enormous size of the insect requires an immense number of veins, but most of them are the mere duplication of independents. The really characteristic veins are given in the accompanying drawing (Fig. 27). At the base there are five strong veins, alternately convex and concave. An independent series interpolated behind the primary reaches nearly to the base. We will consider rather fully the process of specialization of this wing, in order to lead to the consideration of that of the Odonata.

The fact is brought out clearly in this group that there is a close correlation between the shape of the wing and the character of the venation. Shape and venation were doubtless developed together, and each is somewhat dependent on the other. In the adjustment between the venation and the shape, the great length of the wing required the stiffening of the longitudinal axis. This is the one predominating mechanical necessity. All other matters become of distinctly secondary importance.

The Protodonatid wing is somewhat specialized in a number of ways, but in nothing is this carried to the extent seen in the provision for the longitudinal stiffening. The number and position of the longitudinal veins can have but minor importance, because of the regular monotony of their shape, size, and position. Many of them are scarcely more significant than the cross veins. All veins are simple, except the independent systems, and perhaps also the posterior, though all but two, or perhaps three, of the apparent branches are in reality only attached independents.

The one important and characteristic specialization of the Protodonatids, which also gives character to the venation of all the existing Odonata, consists in the limitation of the basal veins to five strong ones, arranged two on either side of the primary. These five veins are situated on alternate elevations and depressions of the membrane. All these veins are connected by cross veins, and the whole forms a very rigid compound truss structure.

In passing from the base toward the apex the arrangement

is disturbed by the interpolation of the independent veins, which crowd off those behind the primary; but these new veins fall into the general scheme, so that instead of five alternating veins there are seven. With the branching of the independents the same process is repeated. All this time the veins have been coming to lie more nearly in one plane, so that the alternation is not so evident. This wing never exhibits the fixity and regularity of alternation seen in the Ephemeridæ, except at the extreme base.

Among the independents one may see quite distinctly a feature which later in the Odonata comes to be very characteristic. It is the tendency toward the production at regular intervals along the outer part of the membrane of a series of pairs of long, unbranched veins (Fig. 27). These can be clearly distinguished from the intervening veins by the fact that the surface of the wing membrane between them is nearly perpendicular to the plane of the wing. With their connecting cross veins they form a simple truss. Some Ephemeridæ exhibit the same tendency, and it is well developed in most Odonata.

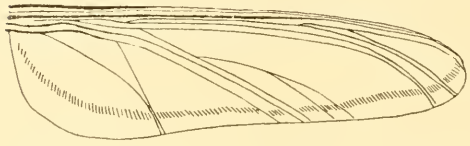

FIG. 27. Diagram of the venation of the Protodonata. The short lines represent independents without basal attachments.

The only other feature worthy of particular note in regard to this venation is the evidence of a tendency to narrow somewhat the space between the primary and the first posterior just before they are pushed apart by the independents. This suggests that at this point arises the arculus, which is the most prominent structural difference between the wings of the Protodonata and the Odonata.

The structures exhibited by the Protodonata are thus exactly in accord with the supposed ancestral position of the group, and clearly indicate, though they do not attain to, the venation of the Odonata.

ODONATA.

There is no group of insects so nearly isolated from all other existing forms as the Odonata. The whole thoracic organization forms a special type. Only the Ephemeridæ possess in common with it the peculiarities of hinge structure and muscle

already described. In the venation we find these groups are absolutely isolated from others by the basal structure and that the Odonata are further distinguished by a combination of characters on the wing disk.

The phrase "combination of characters" is used to express what is often designated facies. It consists of a general plan of arrangement,—elastic enough to allow considerable variation, but only within certain limits both of kind and amount, and often bound up by definite correlations,—and in addition to this general plan a series of details, perhaps never all present at one time, but having definite places and characters when present.

The Odonata are distinguished from the Protodonata by the specialization of three sets of coördinated cross veins forming connectives (Fig. 28). The most conspicuous of these is known as the arculus. The cross veins in this connective may extend entirely across the wing from border to border; the minimum distance is from the primary to the first posterior. When the arculus is present, as in all Odonata, the independents never cross this vein, but end in it.

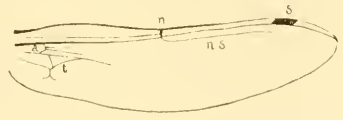

FIG. 28. Diagram of the important features of the wing of the Odonata.

a, arculus; *t*, triangle; *n*, nodus; *s*, stigma; *ns*, nodal sector.

The next most conspicuous connective is the one at the nodus, with the production of which it is quite likely associated. This structure (Fig. 28) is found in all Odonata, and nothing of exactly this type is found in any of the other orders of insects. The connective at this point binds the primary to the veins anterior to it, and it also extends behind the primary and involves one or two of the independent veins.

The third connective is weaker and nearer to the base; it is sometimes so disguised as to be difficult to recognize. This is particularly true in the groups with a well-developed triangle. The character of the connective is much the same as the one just described, only that it connects the hindmost independents with the first posterior. These three connectives are the only constant characters in the venation of the Odonata distinguishing it from the Protodonata.

In order to understand the development of these connectives, we should look, first, for the conditions determining the loca-

tion of the points where the connectives have arisen; secondly, for conditions within the wing favorable to the production of this specialization; and thirdly, for evidence of its utility, by reason of which natural selection will tend to maintain the structure when once produced. In regard to the last item little need be said, as the utility in strengthening the wing is very evident; the fact that the two connectives whose positions and structure are the most uniform are the ones where the utility is the most evident, is distinctly confirmatory of this view.

There is one fact in the matter of the location of the connectives that is at least very suggestive. When the wingpad of one of these insects is pulled a little to one side, it will be seen that the organ does not bend in a straight line, but along a curve corresponding to that shown in the accompanying diagram (Fig. 29). The reason for this is evidently the difference in the stiffness of the different parts of the wing, dependent on its shape. Now with the wingpads placed as they are, a current in the water, or the movement of the insect, would result in a slight bending of these organs back and forth. Along the bending line the cells would have a slightly different environment, and it is possible that the cells of this region might become more and more sensitive to this change until they responded by the production of fully perfected connectives.

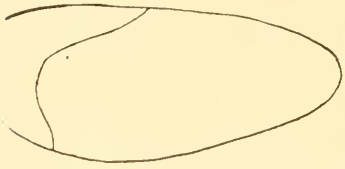

FIG. 29. Diagram showing line of bending in wing case of Odonatid nymph.

How this might be brought about is explainable in two ways. It may be that we have here simply a direct response to mechanical stimulation, which is known in both plants and animals to produce, under proper conditions, very decided hypertrophies. Another, and perhaps sounder, explanation is that the bend resulted in a slight displacement of the principal veins where the bend occurs, so that cross veins occurring at these points are accordingly strengthened. A support to this explanation is the fact, already pointed out, that in the Protodonata the primary and first posterior are somewhat approximated in what will be the arculus region; further, the very evident bend of the two veins in front of the primary at the

nodus, and the approximation of the first and second posteriors at the other connective, strengthen this view.

The Odonata, a group rich in problems of venation, are full of interest, but we shall have to confine ourselves to the consideration of a single one—the development of the structure known as the triangle. This structure constitutes the sole constant difference between the venations of the two divisions of the Odonata. There are almost innumerable points of difference between the venation of typical representatives of these groups, as for instance between *Agrion* and *Eschna;* but within each group there is such diversity that, if we take up one by one each point of difference and trace it out through the whole series, the differences vanish.

The triangle is found among the Odonata only in the Anisoptera, and is, indeed, wanting in all other insect wings. All writers have, I believe, uniformly, and probably correctly, homologized all of the veins in the neighborhood of the triangle with the corresponding veins in the Zygoptera; none have, however, attempted to trace the method of the origin of the triangle. The only discussion of its genesis is the brief one by Comstock and Needham ('98–99, p. 908). I can agree with them as to the nature of the bounding veins—the cubitus and two cross veins—which they were the first to point out, but am not so ready to agree as to the course of development which they aim to indicate by their diagrams. There is no necessity, I think, for conceiving the triangle to have been, as they assume, originally the whole of a quadrilateral cell. Moreover, their figure 65 simply provides for different positions of the triangle, by variations in the angle made by the "inner cross vein" with the basal portion of the cubitus and in that made by the bend of the cubitus; it does not, nor does the wing of any of the Anisoptera, show any quadrilateral cell, nor any transition between a quadrilateral and a triangular cell. This view assumes that by the approximation of the corresponding ends of two cross veins till they meet, a quadrilateral area is converted into a triangular one. My view is that the triangle is formed by the division of a quadrilateral cell into two triangular cells, one of which is the triangle. How, in my opinion, this has been brought about I will explain directly.

I would particularly object to their interpretation of the

relation of the veins they denominate cubital and anal, which has evidently influenced their conception of the method of the development of the triangle. If the ontogenetic evidence afforded by the tracheæ at this point is reliable, the trunk of the first posterior vein (their Cu) should be marked Cu plus A, since both tracheæ occupy the cavity of the vein Cu, and the main trunk of the second posterior designated as the recurrent fourth of the anal, as the trachea indicates in their figure 61 of the hind wing of Cordulegaster. In an insect like this, where the apical portion of the second posterior (Cu of Comstock and Needham) has come to lie so as to be almost a direct continuation of the first posterior (their Cu), it is not strange that the relatively strong trachea of the latter vein should send a branch to occupy the cavity of the second posterior, even to the exclusion of the one that it originally contained. Indeed, a similar shifting of tracheæ occurs at the nodus, as was first figured by Brongniart. The interpretation of this suggested by Comstock and Needham (p. 904), that we here have a case of actual crossing of veins during nymphal stages, is impossible.

But to return to the posterior veins; it must be borne in mind that we are dealing with structures in a region that is constantly liable to suppression, because a little narrowing of the wing would involve the disappearance of parts of these veins. Examples of this reduction are to be seen in many *Anisoptera*, and an extreme case in *Lais*, where both posteriors are involved.

The development of the triangle probably occurred in insects in which this region was of rather more than usual importance in the process of flight. It will be recalled that the character of the stroke as to speed and path determines the relative importance of the different parts of the wing. We can suppose that the triangle first appeared in the wing of a primitive Odonatid, in which there was an increasing functional significance in the anal area; a wing with a venation resembling that of a Calopterygid, which is not far removed from the Protodonata (Fig. 27). The first step in the process was a more abrupt bending backward of the posteriors, which occurs below the arculus, to meet the increasing demands of the anal area. In Archilestes (Fig. 30) we see, in spite of the narrowing of the wing, a similar position of the posteriors. Now if the wing

were broad, so that there must be a large series of veins radiating from the second posterior, the strain on this vein would require the strengthening of the area in front of it, which could be accomplished by the development of a cross vein along the already existing ridge, extending from the second posterior to the hind one of the two independents, or at least along the outer (distal) half of this ridge. In time this vein would come to look like the direct continuation of the first posterior, connecting it with the hindmost independent, as indicated by the lower of the two dotted lines in Fig. 30. An area thus produced agrees in every particular with the condition of the triangle. The second triangular cell resulting from the division of this quadrilateral cell is always recognizable in front of the triangle, and the cell marked *s* by Comstock and Need-

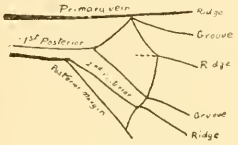

FIG. 30. Portion of the base of the wing of *Archiiestes*, showing probable origin of triangle.

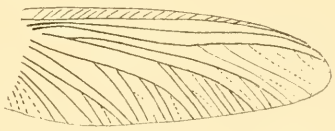

FIG. 31. Venation of Protephemeridæ, with cross veins omitted. Dotted lines are veins that are sometimes wanting.

ham (e. g., their Fig. 62) is thus shown to be bounded by the two posteriors and the basal half of the newly formed diagonal cross vein.

PROTEPHEMERIDÆ.

The Paleozoic insects grouped under this family name possess four equally developed wings. Aside from this character, and the structure of the thorax correlated with it, these insects are not particularly different from the mayflies of the present day. The unusually abundant development of the posterior veins resembles the condition in Ephemeridæ. There seems to be nothing against the idea that we have in this group an early equialar stage in the evolution of the modern group.

The character of the venation is well indicated in Fig. 31, in which all except the cross veins are shown. The latter are very variable in number, rather regularly placed, and quite uniform in size, therefore not particularly significant. In one point, however, these early wings stand in contrast with those of the modern group. It is the absence of free independents. The production of free independents prior to connected ones

would seem to be the natural order of evolution, but this evidence certainly does not point that way.

PALEPHEMERIDÆ.

This family, founded on two Devonian insects, represents a very much nearer approach to the Ephemeridæ of to-day than the group last considered. The fragments are but fractions of the wings, and while we can not know the whole venation, that which is present indicates a shape quite similar to that of the wing of the modern Ephemeridæ. This group can be considered a near ancestral type intermediate between the previous group and the modern Ephemeridæ.

EPHEMERIDÆ.

The mayflies have, in recent years, occupied a very prominent place in the discussions of the subject of venation. No other group with wings that do not fold possesses so many longitudinal veins. One of the easiest ways to trace homologies is to assume that the primitive organ contained as many parts as are found anywhere within the group, and then to imagine that specialization consists chiefly or wholly in the cutting out from the supposed primitive form of such members as is necessary to produce conditions resembling each of the existing forms. On this principle the Ephemeridæ have been chosen by some writers as the nearest living representative of the ancestral stem form.

There is much reason for this assumption in the Ephemeridæ, on account of the rather simple undifferentiated venation possessed by this group. On the other hand, if the geological record is significant in this case, we must conclude that the Ephemerid, instead of being a primitive insect, is really highly specialized, and has the distinction of leaving fossil traces of two distinct steps in the process of its evolution. On the grounds of comparative anatomy there is the objection, that it is more natural to look to an insect with two pairs of equal wings (especially for the production of wings like those of the grasshopper), than to a mayfly, as an ancestor. It is quite as easy to derive all modern venations from one like a Sialid as from an Ephemerid.

The alternation in the level of the veins, resulting in the so-called convex and concave veins of Adolph and his followers, is to be considered as an acquired character rather than a

primitive one, and the explanation of the significance of convex and concave veins, already given, shows that it is not necessary to derive all insects from an Ephemerid, in order to explain the presence of traces of this arrangement in so many different groups.

The veins are not simply convex and concave, as the accounts given would lead one to infer, but there are many peculiar changes of level not easily explained. The wing of Hexagenia, from which Fig. 32 was made, was mounted on a

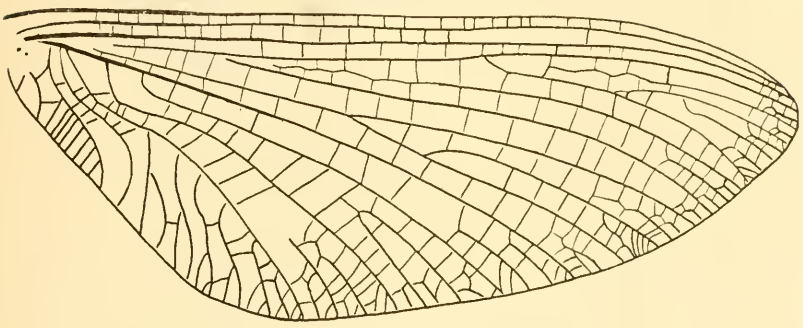

FIG. 32. Venation of *Hexagenia bilineata.*

slide, and vertical measurements were made, by means of the graduated fine adjustment screw of the microscope, at the points where the veins intersected twelve equidistant lines crossing the wing at right angles to the costa, to ascertain the relative heights of these several points. The results are given, in hundredths of millimeters, in the following table. The first column is the anterior and the last the posterior marginal vein; the intermediate columns represent all the veins (except the minute apical independents) occurring back as far as the first posterior. The first line is nearest the tip.

Table showing the Variation in the Level of the Veins.

4	2	7	2	6	2	6	--	--	--	--	--	--	--	--	--	5
10	7	10	3	6	0	10	7	7	3	--	--	--	--	--	--	8
16	6	13	4	15	6	14	9	0	8	0	8	--	--	--	--	6
12	12	18	3	16	4	17	--	4	14	1	12	4	13	--	--	4
9	9	20	7	--	--	12	--	6	18	3	24	7	15	19	--	11
2	2	22	11	--	--	19	--	2	20	--	18	3	9	13	24	18
11	0	16	4	--	--	28	--	1	--	--	15	2	7	27	22	15
18	5	8	4	--	--	26	--	8	--	--	25	2	--	24	413	26
29	8	23	10	--	--	4	--	6	--	--	22	2	--	27	5	28
28	6	28	15	--	--	--	--	--	--	--	32	3	--	31	3	12
26	6	26	24	--	--	--	--	--	--	--	30	6	--	29	14	4
16	8	19	--	--	--	--	--	--	--	--	--	--	--	37	--	9

The costa had been crushed in the region of lines 4–6, but otherwise the wing is normal. The character of some of the irregularities here indicated is shown much more clearly on the accompanying figure of a fragment of the same wing (Fig.

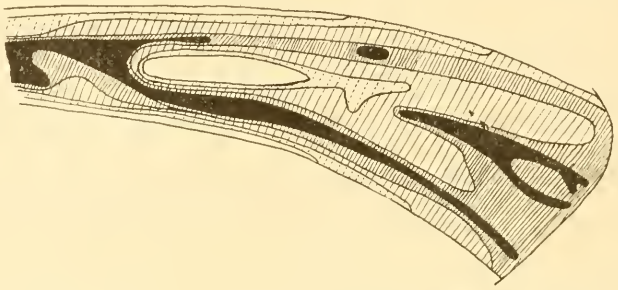

FIG. 33. Fragment of the wing of *Hexagenia bilineata*, showing by contour lines and shadings the heights of the various portions of the wing. The unshaded areas are the highest, and the solid black the lowest.

33). This shows the region between the primary vein and the first strong convex vein behind it, the one indicated by the twelfth column of the above table. The levels are shown by contour lines, the black and shaded portions being lower than the unshaded part, as the figures in the table indicate. These data show that there is without question more in this matter than alternate veins of different character. The mechanical problem of producing the adequate stiffness of the wing is the most important factor.

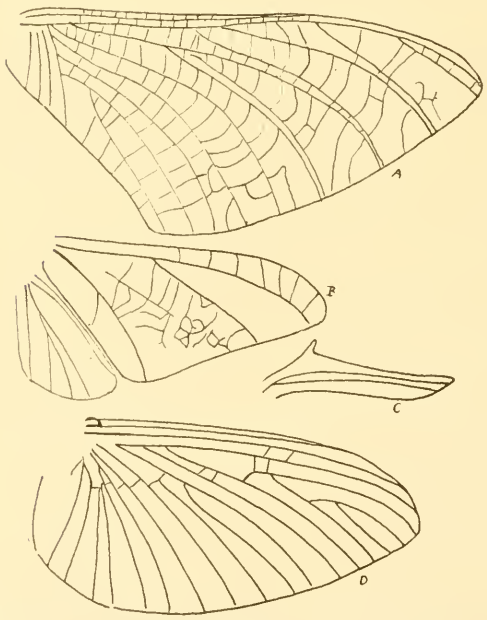

FIG. 34. Abnormal venations in Ephemeridæ after Eaton. A, *Palingenia*. B, *Elassoneura*. C, *Callibætis*. D, *Cœnis*.

Aside from the matters already discussed and those arising out of the reduction of the hind

wing, the wing of a mayfly exhibits but little that is peculiar. The venation is essentially of the primitive type. There are among the mayflies a number of interesting cases of reduced venation. In Palingenia the arrangement of certain of the independents in pairs, in the same manner as is common in Odonata, is carried to a greater degree of perfection than in any other insect, since it involves here the suppression of the adjacent independents. In the allied Elassoneura the suppression of longitudinal veins is carried to the farthest extreme: there only the marginal, the primary, and a single independent and posterior vein remain. In Cænis and related genera the reduction and finally complete suppression of the hind wing have resulted in a very peculiar wing shape and venation, suggesting somewhat Adolph's figure of a theoretical dipterous venation. Among these insects we have the best examples of the suppression of the cross veins.

The homologizing of the veins in the wings of different genera of Ephemeridæ has been very well done by Eaton, but in the comparison of the veins of the front and hind wings, Redtenbacher is more successful. He has also indicated the correct homologies with other insects.

STENODICTYOPTERIDÆ.

The fossil insects of this group, made known by Brongniart, are of large size, and show a relatively simple venation of large veins, with the membrane finely and densely reticulate. These characters make a very distinct group. The arrangement of the larger veins is according to the simple primitive type, and so does not closely indicate any relationship in particular. All the fossils have the wings spread or broken in such a way that it is difficult to say whether the insects could fold the wings or not. The character of the venation, as far as regards the larger veins, is shown in Fig. 35.

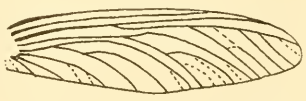

FIG. 35. Diagram of the venation of the Stenodictyopteridæ, omitting the very dense reticulation. Dotted lines show veins sometimes wanting.

HOMOTHETIDÆ.

The study of fossil insects is beset with so many difficulties that it is not strange that there should be room for great difference in opinion. The present group, as limited by

Scudder, contains insects with very different facies, and has been somewhat dismembered by later writers. The characters given by the author of its name may be stated in a few words. The wing possesses an entirely simple primary vein, free from both the anterior and the independents. This character is shared by only the Protodonata and Protephemeridæ among the Paleozoic insects. The condition is not always to be made out with certainty in a fossil specimen, and so there may have been errors in identification in this group, but it is not likely that all the cases are errors. The character is not as significant, according to our present conceptions of the veins concerned, as it might be under other theories of venation, but it is about as good as any to be found in such an undifferentiated type of venation. The accompanying diagram (Fig. 36) shows as well as may be the character of the venation in this group. I agree with Scudder that the group has no very evident affinities with any existing insects.

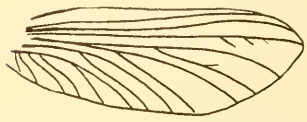

FIG. 36. Diagram illustrating the venation of the Homothetidæ. The abundant and variable cross veins are omitted.

PALEOPTERINA.

The characters assigned to this group are shown in Fig. 37. The relatively small size of the first group of independents distinguishes it from the two following families. I am free to confess that this character appears to me to be of very little value, and quite insufficient to differentiate groups larger than genera. Certainly, in living forms with a neuropterous venation more would be required. I am inclined to believe that venation does not furnish good grounds for classification among these insects. If we depended upon the venation, it is probable that closely allied forms would be separated and more distant ones united. Such a form as *Propteticus* shows a body structure that would at once separate it from the mass of the insects of

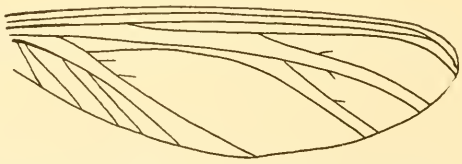

FIG. 37. Diagram of the venation of the Paleopterina, omitting the cross veins and the most variable of the longitudinal veins.

that time, and there is but little reason to think that all the other insects grouped under this head have a similar structure. One should not give too much attention, therefore, to the classification, if he desires to make a just interpretation of the venation. Whole series of families whose differentiation was not associated with flight can, for the purposes of the study of venation, be considered as a unit. The same dictum will apply to the higher groups as well as to these lower forms.

XENONEURIDÆ.

The insect which is the type and sole member of this family is one of the smallest of the Paleozoic fossils, and possesses the simplest venation. It seems to be distinct enough from everything else to deserve a separate place. There is nothing so unusual in the venation, however, as would cause surprise if further discoveries should connect it with the common Neuroptera. As will be seen by the accompanying sketch (Fig. 38), the venation is simply a reduced form of the primitive type.

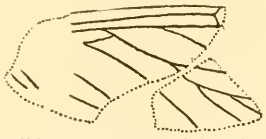

FIG. 38. Remains of the wing of Xenoneuridæ, after Scudder.

HEMERISTINA.

This group seems to be another case of a very composite family brought together by the character of the venation. The character upon which it is founded is the relatively greater size of the first group of independents, as compared with those that follow. This difference will be clearly seen by comparing the accompanying diagram (Fig. 39) with that of the Paleopterina (Fig. 37). Members of the latter family, as well as of the one now under consideration, have been identified by Brauer ('86) as Sialids.

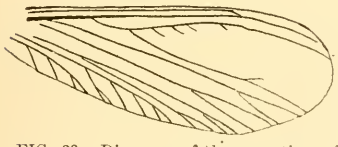

FIG. 39. Diagram of the venation of the Hemeristina, omitting cross veins and most variable independents.

GERARINA.

The character upon which this group is founded, the direct attachment of a number of independents to the primary, seems more likely to prove of value in making a natural classification,

than the venation characters in the groups just considered. The venations are all comparatively simple, but quite variable as to number of veins. In the accompanying diagram (Fig. 40), the venation shown at the anal angle does not fairly represent this region in all the insects placed in this family; but accuracy on this point is impossible at present, because of the fragmentary character of the specimens.

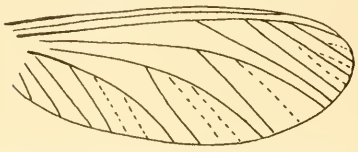

FIG. 40. Venation of Gerarina. The dotted lines show the veins that are sometimes absent.

PLATYPTERIDÆ.

This group of Paleozoic insects, as defined by Brongniart, includes the genus Lithomantis, placed by Scudder in Hemeristina, and a large number of similar many-veined forms which usually have dense reticulated veins, something after the order Stenodictyopteridæ, but not so dense nor with very numerous close-lying longitudinal veins. It will not be necessary to figure the venation, as it is not essentially different from Paleoperinæ or Hemeristina. Brongniart compares these insects with the Sialidæ.

PROTOPERLA.

The insects placed in this group by Brongniart seem to belong to Scudder's Hemeristina. They possess a primitive, and somewhat reduced, venation, and might easily present an ancestral form of the Perlidæ. They show no specific character, however, that will afford undoubted evidence of this relationship. This is perhaps what should be expected, since the venation in the Perlidæ is of such an undifferentiated character.

PERLIDÆ.

The Perlidæ possess two pairs of independent wings lying over each other and flat on the back when at rest. The front wings thus in a measure serve as a protection for the rather more delicate, and usually distinctly broader, folded hind wings. In one case, *Nemura trifasciata*, the front wings have become reduced to a semi-rudimentary condition, giving the insect somewhat the appearance of certain Cerambycidæ with abbreviated elytra.

The venation of the two wings never exactly corresponds, but approaches correspondence most nearly when the wings are of approximately the same size and shape, as is true in some species of *Perla* and *Nemoura*. The family possesses a few quite characteristic venations and shows certain very evident tendencies, but there are intermediate forms so completely connecting the various types that, with the diversity, it is difficult to define the Perlid type of venation except by negations. Even such a wing as that possessed by the Paleozoic Protoperla would not be particularly anomalous in this family, if it existed on an insect at the present day.

One of the most evident and most constant tendencies noticeable in these wings is the production of a strong cross vein

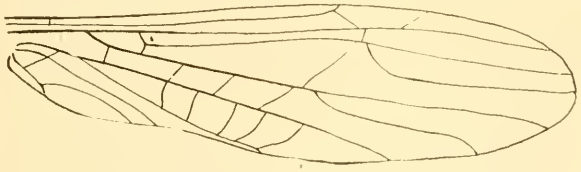

FIG. 41. Venation in *Nemoura*.

beyond the middle, corresponding quite strictly with the principal connective in the higher groups. This connective is not very evident in Pteronarchys, where the venation is of the primitive type, nor in such forms as Eusthenia, where the veins have come to lie parallel with the front margin, forming long rectangular cells arranged as bricks in a wall. It is most evident in *Capnia* and in the hind wings of *Perla*.

The ladder-like arrangement of veins is a very characteristic thing in a Perlid wing. This consists of a series of numerous, closely placed cross veins, usually occupying two interspaces, as in Fig. 41. This ladder serves to locate the first posterior vein, the sub-median of Pictet, which is the middle vein of the ladder. There is practically no difference of opinion regarding the homologies of the veins in this group.

TERMITIDÆ.

The peculiarity of the venation of the Termitidæ is in part dependent on the extremely short period the wings are used—a structure that will wear well not being required—and in part on the manner of specialization, whereby the posterior two thirds practically becomes veinless; all the formative material is apparently appropriated by the primary and the veins

adjacent to it. The region in which the veins are thus weakened, or nearly suppressed, is subject to so much variation that it is impossible to give a diagram that will clearly show the condition.

As seen in Fig. 42, the venation is of a primitive and simple sort, such as might be had by the suppression of the cross veins of several of the Paleozoic types of venation, and in some cases the suppression also of a few of the longitudinals. This wing

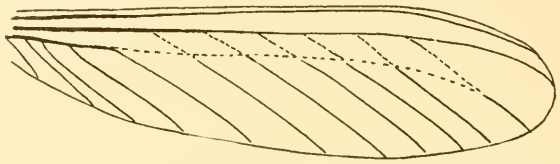

FIG. 42. Diagram illustrating the venation of the Termitidæ. Dotted lines indicate alternative attachment of the independents. The number of these is somewhat variable. Cross veins are omitted.

shows clearly the instability of the basal attachment of the independents, since they may be attached as branches to the primary, or appear as a continuation of the posterior vein.

Whatever differences of opinion there have been in homologizing these veins, they have all arisen from the idea that the independent arises from the base like the other veins. There are always five veins only—the primary, an anterior, a posterior, and the two marginals. The large size of the wing-roots, and the feebleness of the attachment of the wing to them, are characteristic features of this group.

EMBIIDÆ.

The small family Embiidæ deserves a more careful study in regard to the nature of the articulation of the wing. The very anomalous position of these organs on the segment makes this particularly desirable. The venation presents no difficulties of interpretation, as will be seen by the accompanying diagram (Fig. 43). The feebleness of the veins in the posterior part of the wing allies these insects with the white ants, with which they are commonly associated. The general direction of the independent veins, however, makes their venation very distinct from that of the Termitidæ.

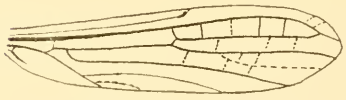

FIG. 43. Venation of Embiidæ. Dotted lines indicate veins that may be sometimes absent.

There do not seem to be sufficient grounds for giving the cross veins the value of branches, as has been done by Comstock and Needham.

PSOCIDÆ.

As far as the venation is concerned, the Psocidæ are very completely isolated. There is a striking superficial resemblance between the venation of this group and that of the Hymenoptera. Only when one attempts to compare carefully the two is the illusion dispelled. No other group approaches the Hymenoptera so closely in the shape of the wings as the Psocidæ. It may be that the similarity results from the veins adapting themselves to meet an identical mechanical condition due to the shape of the wings.

The typical venation, such as seen in Psocus, is given in Fig. 44, and the scheme of venation of both pairs of wings in Fig. 45. From the diagram it will be seen that, excepting the Embiidæ, there is less diversity than in any of the groups of lower insects, and in this respect the Psocidæ are quite comparable with the Hymenoptera or other higher groups.

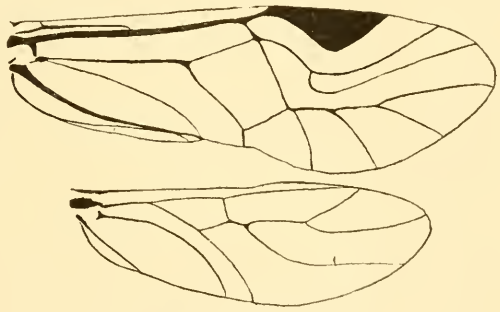

FIG. 44. Venation of *Psocus*.

The homologizing of the veins in Psocidæ has been a matter of controversy. There have been two questions: One, the comparison of the veins of the front wing with those of the hind wing; the other, the comparison of the venation of Psocid wings with other venations. The former is often avoided by disregarding the hind wing entirely. There are two principal theories regarding the homologies of the front and hind wing. According to one theory the primary vein is nearly suppressed, as it appears to be in the hind wing of Psocus (Fig. 44); according to the other, this vein is the one running nearly to the tip parallel with the margin. A comparative study of the wings of other genera shows that the latter is clearly the case.

The other question is more complicated. Recent studies

differ greatly. Thus, Scudder considers the veins I have called independents, to comprise all the branches reaching the margin in the outer half of the wing. Redtenbacher and Brongniart supposed that only the first two branches correspond with my independents, the others being branches of the first posterior; Comstock and Needham regard the first two as branches of the primary, the next three as independents, and the last two as the first posterior. I believe that Scudder is right in regard to this question, and think his conclusion is confirmed by a comparative study such as is epitomized in Fig. 45. If these two problems are correctly decided, the rest of the homologizing becomes a very easy matter. The accompanying diagram (Fig. 45) gives the plan of the venation of both wings as made out by a comparative study of all the genera, fossil and modern.

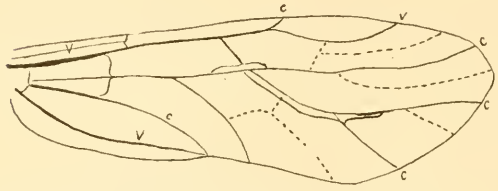

FIG. 15. Diagram of the venation of Psocidæ. Constants of the front wing are indicated by solid lines; those of hind wings by letter *c*. Variables of front wings are represented by dotted lines; those of the hind wings are indicated by the letter *v*. Brackets indicate alternative attachments of veins.

SIALIDÆ.

The Sialidæ possess the most primitive venation of all living insects. The variation within the family is by no means as great as is found in the earliest fossil insects. The specialization of the group appears to have been the setting of rather narrow limits to the variation, instead of the production of any special feature that can be recognized. None of the known Paleozoic insects possesses a venation that falls within the range of this family, though nearly every feature in the venation can be duplicated in those ancient wings. The character of the venation may be seen in the accompanying diagram (Fig. 46). There is evidence of a tendency toward the reduction of cross veins and the development of a number of large cells in the disk. The manner in which the

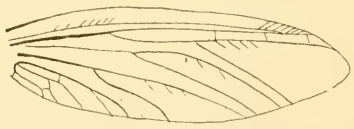

FIG. 46. Diagram of the venation of Sialidæ. Cross veins and the most variable of the longitudinals are omitted.

second and following posteriors are bound together is also characteristic of the neighboring families. A very similar structure seen in the Diptera is not the same in origin.

The homologies of the veins as worked out by Redtenbacher, Brongniart, and Comstock are essentially alike. This is one of the very few cases where it can be said that there is general uniformity of opinion.

HEMEROBIDÆ.

Each of the seven subfamilies constituting this group possesses a venation that is quite distinct from the others; though the definition of some subfamilies is difficult, because of the great diversity of their contents. The venation is not so primitive as in the Sialidæ, as in every case there is evidence of some particular specialization.

A character seen in all members of the family, except in the Coniopteryginæ, is a tendency to excessive production of independents. These are mostly short veins attached in such a way as to appear as branches, or rather furcations, of the longer veins. This tendency is carried to the extreme in certain Myrmeleoninæ.

The tendency to coördinate, or approximately coördinate, cross veins is seen in Mantispinæ, Hemerobinæ, and Chrysopinæ, always associated with a more or less evident reduction. The tendency toward reduction extends to the longitudinal veins in most cases, though in the Mantispinæ these remain very numerous. The smallest number of longitudinal veins is seen in the Chrysopinæ; in Coniopteryginæ there is almost an entire absence of cross veins. Only in these extreme reductions are the veins practically constant. Ordinarily, as in most neuropterous venations, there is much variation, even in the same species.

There has been scarcely any difference of opinion as to the homologies of the veins. The very evident relationship with the preceding family prevents any very serious mistakes. In smaller matters there is room for some difference of judgment, but these need not be considered here.

PANORPIDÆ.

The wings in this family exhibit a remarkable degree of uniformity for an insect with numerous veins, contrasting strongly with the nearest allies. The cross veins show a great

deal of diversity, but these have not yet become very significant in venation.

The character of the venation may be seen in Fig. 47. As in the preceding two families, there is no room for controversy regarding the homology of the veins. The very close resemblance between this venation and that of a Tipulid makes it seem possible that this group is somewhat close to the ancestor of Diptera.

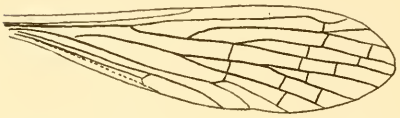

FIG. 47. Diagram of the venation of Panorpidæ. All cross veins not constantly present are omitted.

PHRYGANEIDÆ.

The Phryganeidæ are of peculiar interest, because the venation of some of these insects is almost identical with that of the lower Lepidoptera. They are probably nearly related to the ancestor of that group, and possibly to that of the Hymenoptera also. These suggestions are made the more probable, because in the one case there is a series of pointed-winged Phryganeidæ with reduced venation, quite comparable with the Tineina in the Lepidoptera, and in the other case a series of hooks by means of which the wings are hooked together, much as in Hymenoptera; in the latter case the venation resembles that of the Hymenoptera more closely than any other venation does.

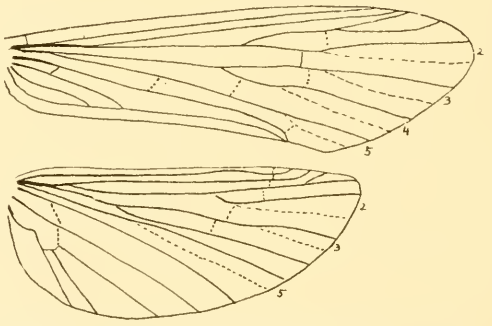

FIG. 48. Diagram illustrating the venation of the larger Phryganeidæ. The numbers are those used by McLachlin.

The character of the venation in this group is shown in the accompanying diagrams (Figs. 48–50), on which for conven-

ience have been placed the numbers employed by McLachlin ('74–80). The longitudinal veins compare very closely with the venation in the Panorpidæ, but the cross veins have been

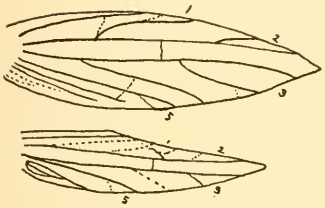

FIG. 49. Diagram of the venation of the pointed-winged Phryganeidæ. The numbers are those of McLachlin.

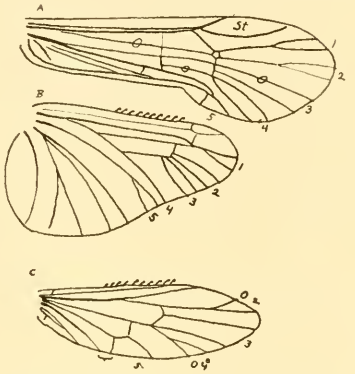

FIG. 50. Diagram of the venation of Phryganeidæ.
A and B, *Cloropsyche;* C, hind wing of *Helicopsyche;* O, veins that must be suppressed to produce the venation of Hymenoptera; *St*, area in which the stigma is supposed to be developed.

reduced to a small number, which are very constant in position. The homologies are very evident, and have been uniformly interpreted correctly.

HEMIPTEROIDEA.

Under this title Scudder ('85) has assembled a series of insects belonging to the Paleozoic era which have evident relationships with the Hemiptera of the present day. It is not at all certain that some of them should not be placed at once in the Hemiptera, as is done by most authors. The one possessing the least evident similarity in venation to the Hemiptera, *Eugeron*, possesses mouth parts that appear to resemble very closely those of a true hemipterous insect. The venation of this insect resembles the ordinary undifferentiated type. The peculiar development of the anal area precludes the possibility of folding, and resembles the condition in the front wings of Blattidæ. It is evident that the wings were capable of flexion.

The insect nearest like modern Hemiptera is *Phthanocoris*, from the Carboniferous, known only by the front wing. This shows very distinctly all the characteristics of the Heteroptera

of the simpler type, thus indicating that the heteropterous wing was very early developed. There is even ground for supposing that the Homoptera were at one time heteropterous, though of course this is improbable.

Most of the remains supposed to be of this group are very unsatisfactory for the study of venation, and it is more than possible that some of the fossils supposed to be homopterous do not, in fact, belong here at all. It will be quite impossible to give a satisfactory diagram illustrating the venation of this group.

ORTHOPTEROIDEA.

The oldest known fossil insect shows evident relationship with the Blattidæ. Numerous similar forms, and others suggesting the Phasmidæ and Acrididæ, constitute the fossil group usually placed in the Orthoptera, but considered by Scudder as not sufficiently differentiated from other Paleozoic forms to warrant the assignment.

The Palæoblattidæ, which have been considered by some authors as representing the most primitive insects, have the most characteristic and distinct venation of any of the Paleozoic insects, the other Orthopteroidea being more like the other insects of that era. If the position is well taken that the Palæoblattidæ are the most ancient of known insects, then the first differentiation was that which separated off the other Orthoptera, from whose ancestral form the other groups arose later. A more reasonable hypothesis, however, is, that the Palæoblattidæ represent an early specialization, the extreme member in a series that specialize in such a way as to provide for the protection of the hind wing by the front wing, the cause being the same as that by which the Hemipteroidea were specialized. The difference between these groups concerns chiefly the mouth parts, but there are differences in venation resulting from the adoption of a somewhat different method of coming to rest.

In the Palæoblattidæ the thickening of the wing was brought about by the enlargement and strengthening of the longitudinal veins, causing them to lie quite strictly parallel, and resulting in a very favorable object for preservation in the rocks. It thus comes about that there is a large series of these fossils known, and their venation is very easily made out.

The wings are quite free from cross veins. The character of the venation is shown in Fig 51.

The remaining Paleozoic Orthopteroidea exhibit a general resemblance to the insects just considered, but are distinctly more like other insects of the time. Cross veins are always present. The longitudinal veins are proportionately very much smaller in diameter and not so strictly parallel, but they nevertheless resemble the Palæoblattidæ more nearly than do any other insects.

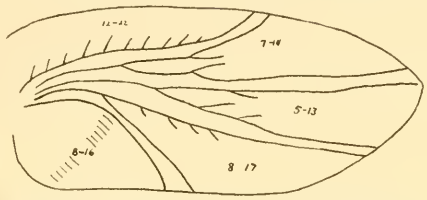

FIG. 51. Diagram of the venation of the Palæoblattidæ. The figures indicate the range of variations in the number of veins in each area.

ELYTROPTERA.

This group is unquestionably unnatural from a systematic point of view, since there are no grounds for supposing that there is any close relationship between either of the orders here assembled. Each order has responded in much the same way to the requirements of a similar environment, and so they present many characters in common. The name here proposed (Elytroptera) is therefore simply one of convenience.

The anterior wings show a tendency toward the suppression of the venation, owing to the membrane becoming throughout vein-like in texture, so that the whole surface is more nearly uniform. The posterior wings come to exceed in size the anterior, and so are folded enough to be covered by them, the venation becoming involved in the folding mechanism. In this group, therefore, the study of the folding and its influence on venation is of paramount importance.

BLATTIDÆ.

The specialization of the Blattidæ from the Palæoblattidæ consists in the thickening of the front wings, the perfection of the posterior region of the hind wings, and the changes incident to folding. The effect of the former process is rather the suppression of venation when carried to the extreme, and need not be considered in detail.

The perfection of the folds is of more significance. The nature of the folding may be seen in Figs. 52 and 53. Comparing these figures, it will be seen that the wing is divided longitudinally into an anterior unfolded and a posterior folded area; that the folded area is entirely divided into fields and entirely concealed under the anterior area; and further, that each field embraces a longitudinal vein and an independent in front of it. Probably the first fold is the original one, and the following folds represent wrinkles in the posterior area separating tracts, each of which, after becoming successively possessed of a longitudinal vein and the independent accessory, became a definite flat field. According to this view, the whole plicated area is developed in adaptation to the folds; indeed, the veins are produced in the way they are, in order to perfect the folding of this part of the wing. In different members of the family there may be a greater or less number of folds, and always a corresponding augmentation or diminution of the number of veins in this region.

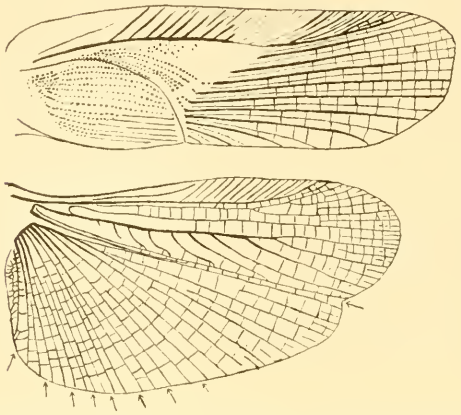

FIG. 52. Venation of a species of Blattidæ from Madagascar. The front wings show a structure resembling the Hemiptera. Arrows indicate lines of folding in hind wing.

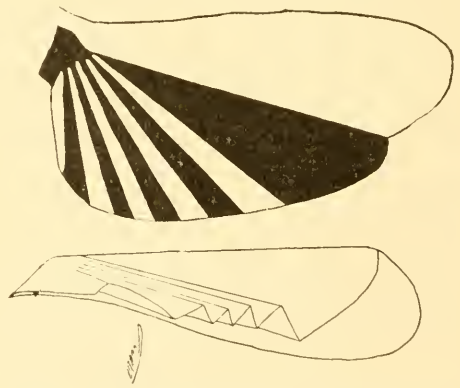

FIG. 53. Diagrams illustrating the folding of the hind wing of a cockroach. Black areas are those reversed in folding. Central figure shows folded wing from beneath: lower figure a cross-section of a folded wing.

There is another specialization in the hind wings of certain cockroaches that is interesting, since it shows in an unmistakable way the formation of new veins in a folded area, and because it gives us a hint of the way in which the Forficulid wing must have been produced. This matter was first worked out by Saussure ('68) in the manner indicated on the accompanying diagram (Fig. 54). In the evolution of *Diploptera*, the wing is supposed to have successively passed through a series of stages similar to the conditions shown in the series of genera illustrated in Fig. 54. In this way the whole of the folded tip of the wing is shown to have come from an increase in size of the minute triangular bit of membrane occupying the angle of the principal fold. In none of these forms is the plicated area at the tip provided with veins, except the extreme member of the series (*Diploptera*), where they must have been produced simultaneously over the whole area, just as the reticulations of cross veins are.

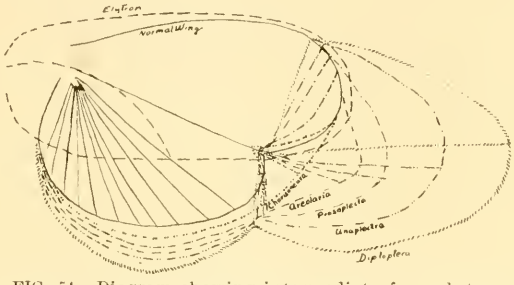

FIG. 54. Diagram showing intermediate forms between the normal hind wing and that of *Diploptera*, showing the evolution of the plicated tip.

The lenticular anal field of the front wings of Blattidæ, which was already well developed in the Palæoblattidæ, is clearly comparable with the anal area of all orthopterous and hemipterous insects, and is also clearly homologous to the folded anal area of the hind wings. This anal field is always very distinctly marked off from the rest of the wing by a line that is usually very much thinned and often quite transparent. Another line of the same character is to be seen just behind the primary vein. Between these two lines the area is occupied by independent veins, usually clearly distinguishable as forming three groups. The third of these is often specialized so as to resemble a reverse of the many-branched primary. Because of this peculiarity this vein has been identified as vein VII by Redtenbacher and by Comstock and Needham, but the interpretation of Brauer seems to be more sound and to accord

better with the paleontological evidence. The posteriors belong wholly to the anal field, and are the veins modified for the common anal foldings.

FORFICULIDÆ.

The earwigs possess a venation that is entirely uniform, as far as known, but remarkably different from anything known

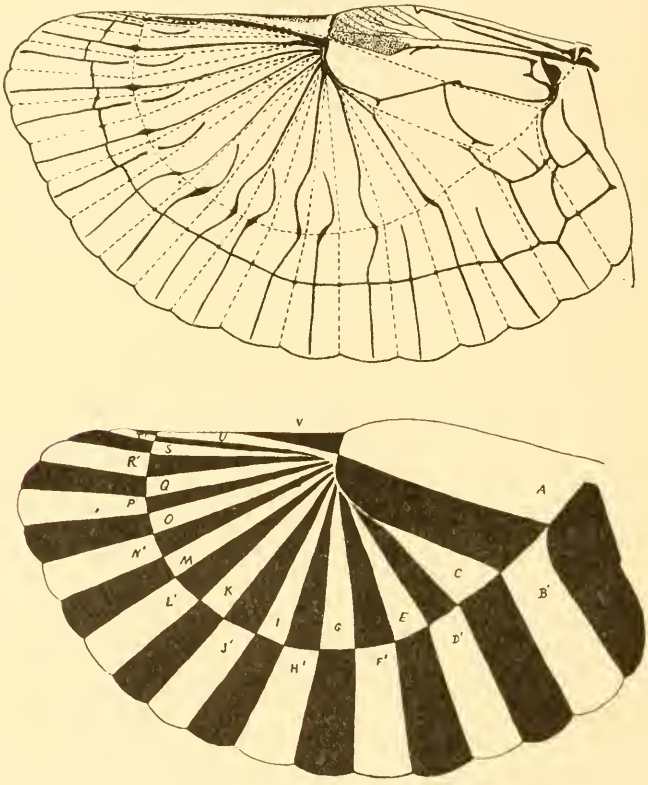

FIG. 55. The venation and folding of Forficulidæ. The dotted lines show the lines of folding. The black areas are those reversed in folding. Letters are to identify areas.

elsewhere. The general features of the venation have often been figured, but the details necessary for the interpretation of the venation have never been shown. The whole venation depends upon the very peculiar method of folding. The wing is packed away into very small space in the manner shown in Figs. 55 and 56. The piece A (Fig. 55) is attached to the body in the manner in which wings are

usually attached, and moves in the same way. Piece B, shown in black, bends down under A when released, because of the twist of the vein, which I interpret as the first posterior; this crosses from A to B at about the middle of their length (compare Fig. 56). The other veins that are under tension when the wing is spread are the radiating veins given off at the distal end of B. These elastic veins constitute the whole mechanism of folding. The process is as follows: On the relaxation of the muscle that pulls on the anterior marginal vein to keep the wing expanded, the piece B folds downward. The pull of the elastic radiating veins folds downward the piece V, which previously resisted the strain when the wing was flat, folding the wing along the line beginning between V and A. The apical part of the wing falls into folds alternating in direction and determined by the position of the veins, in the manner indicated in Fig. 55. While this folding process goes on, the piece B is being folded along the line between A and B into a position directly beneath A, and all the rest of the wing takes its position between the two (see Fig. 56).

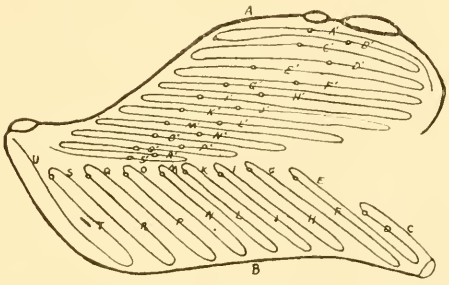

FIG. 56. Section across the middle of a folded wing of *Forficula*. Letters indicate areas, and correspond with those on Fig. 55.

When the wing is completely folded, the under sides of A and A′ are in contact, and then follow in regular order B′, C′, D′ and so on. Likewise, counting from the body outward, we find first B, then C, D, E, etc., in regular order.

In spreading, the pull of the front margin straightens out A and B, thus spilling out, as it were, downward and forward, the rest of the wing, which is finally pulled into position as the piece V is straightened out at the end of A.

How this very complicated mechanism was brought about is not an easy problem to solve. The common idea that we have here simply the fan-like fold of the grasshopper doubled twice after folding, in order that it could be better stowed away, is certainly entirely wrong, as the figures and the description of the process show. The place where the radiating veins at

the end of B are attached can not be compared closely with the basal attachment of the radiating veins in other Orthoptera. The real basal structures are found on areas A′ and B′. The correct interpretation of the parts of this wing is probably that suggested by Scudder, who compares the folding with that described by Saussure in the Blattidæ. This suggestion has never been followed out, though the subject of the homology of the veins has been discussed by both Brongniart and Redtenbacher.

According to this theory, the added apical areas, which remain in Blattidæ much smaller than the rest of the wing, become in this insect the major part, everything beyond C and C′ being comparable with these areas. The increase in size occurs in the posterior of the two areas, the anterior being represented by the area V. The development of an earwig wing from the more complicated conditions found in the Blattidæ is not much more difficult to understand than the first production of the complex cockroach type. We only need to imagine that the hind apical area, becoming larger, wrinkles up fan-like when it is folded, and that the veins which develop in the membrane adjust themselves so as to facilitate this folding. The lengthening of the membrane in this region would result in the bending back of the tips, with which new modification the veins would accommodate themselves, and finally the increase of this area would so encroach upon the anal region that it would lose its original fold, or perhaps, rather, merge it with the fold that brings the tip of the wing backward.

This explanation accounts for the difference between the character of the veins in areas A′ and B′ as compared with the corresponding areas further on, and seems to present no particular difficulty of any kind.

There are three kinds of veins in the apical region of the wing: One having basal attachments; another, alternating with them, and scarcely more than half as long, without basal attachments; and a third consisting of cross veins. There is a slightly different union between the cross veins and the two kinds of longitudinal veins, indicating a real difference between the longitudinals. The shorter ones have much the appearance of independent veins, and the others probably have grown out from the vein bordering the fold, in the same way that the principal veins arose from the base of the wing. It would be

hard to determine the order of the development of these veins, but it is possible that it is from the front backward.

Both Redtenbacher and Brongniart have attempted to homologize the veins of these insects, and agree in considering the radiating veins comparable with the radiating veins in grasshoppers. The posterior would thus be their vein IX as well as the rays. It is very difficult to conceive the stages in the migration of the vein IX out beyond the tip of the independent, and, besides, the folding of this wing is fundamentally different from the folding of the anal area of Orthoptera.

ORTHOPTERA.

The Orthoptera, omitting the two families just considered, are, as far as differentiation is indicated by the venation, much simpler than the preceding families. The Paleozoic ancestors bore the same relation to the Palæoblattidæ that the modern forms do to the Blattidæ. We know that the venation is one capable of extreme specialization, as is shown by the remarkable stridulating organs in the males of Gryllidæ and Locustidæ (see Fig. 25, showing the wing of the common cricket).

The shape and function of the front wings are not such as to favor the development of any new or more definite venation, and the hind wings are taken up with the arrangements for folding, which requires and maintains a monotonous repetition, instead of high specialization. There is great similarity between the venation of the Blattidæ and that of other Orthoptera, except that the Blattid venation is rather more definite and complete. There are many examples of reduced venation among the Orthoptera, but in no case is there reduction with specialization, except it be for some other function than flight.

The Phasmidæ are mostly apterous, and when possessing wings, these have been so reduced that only the more important of the longitudinal veins remain. Under these conditions, unless the wing is too much reduced, the characteristics of the orthopterous venation are clearly seen, especially in the folded area of the hind wing.

The Mantidæ possess the least differentiated wing in the whole order, and the greatest number of longitudinal veins. These are extremely variable, as in the Neuroptera, and very regularly placed.

The Acrididæ show something of a reduction in the number

of veins, as contrasted with the Mantidæ. They also present in most cases, a modification of the independent region in the form of an enlarged cross vein, or an abrupt branching of the independent veins, which disturbs very strikingly the uniformity of the wing. The veins are extremely variable, however, so that there can be said to be here a tendency toward a specialization, rather than one already accomplished.

The Locustidæ and Gryllidæ have very simple hind wings, but the front wings are distinctly changed for the production of the stridulating organ in the male, and a corresponding though less pronounced change in this structure in the female. In the Locustidæ there has been a great reduction in the num-

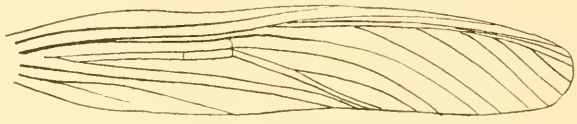

FIG. 57. Diagramatic representation of the wing of an Acridid.

ber of the independents without much decrease in the size of the areas, and there are fewer cross veins, thus making numerous larger cells rather than a dense reticulation. In the Gryllidæ the median area is almost entirely suppressed, leaving only a few independents spreading out fan-like.

The venation throughout these families differs from that in Blattidæ, in that the independents of the first group are attached as branches to the primary. They resemble in this respect their Paleozoic ancestors. In the matter of the homologies of the veins, there is no difficulty in comparing these venations with those of Blattidæ, so the same questions arise as did in that family.

HETEROPTERA.

The Heteroptera stand in a somewhat intermediate position between the Orthoptera and the Coleoptera. With the former they agree in the leathery texture of the front wings, and with the latter in the close application of the wings to the body when at rest. In neither case is there close similarity, however—nothing to suggest the probability of a genetic relationship. It is likely that the order of their specialization was that which the fossil remains thus far known indicate, viz.,

Orthoptera, Heteroptera, and last of all the Coleoptera. That they were not derived one from the other is quite evident, but the exact source of the groups is unknown.

The characteristic of the front wing of Heteroptera is the division of the area of the wing into three regions, by the separation of the clavus and membrane from the rest of the wing known as the corium. This division is very evidently the result of the action of two distinct influences. The first is the same as that which separates the anal field in the Orthoptera. It is probably an adaptation to permit the flexion of the wing without the excessive narrowing that exists in Coleoptera. The transverse line, that marks off the membrane, is associated with the overlapping of the tips of the wings. In the wing of a cockroach (Fig. 51) we see an exactly similar modification of the front wing, such as must have occurred in the first specialization of the heteropterous wing. The separation of the embolium is evidently produced by the line that is seen in Orthoptera, just behind the primary, and the cuneus may possibly represent a stigma.

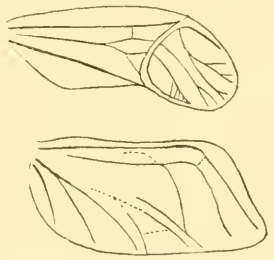

FIG. 58. Diagramatic representation of an Heteropterous venation.

The venation of the front wing (Fig. 58) is very much obscured. The primary is usually at some distance from the front margin, and the posterior is on the edge of the clavus. Between these is a single independent, which forks at about the middle of the wing; each of these forks is connected to the adjacent vein by means of a cross vein. Usually these veins can scarcely be made out, and it may be that in other cases, where the venation is obscure, other independents may also extend to the corium.

At the edge of the membrane there is much variation. My interpretation of the structures here presupposes two transverse veins bordering the division line between the membrane and the corium, one belonging to each. These may both be considered as accessory veins. The inner one comes into connection with both the primary and the independent, and in some cases many become quite prominent. The membrane vein runs parallel with the inner one, and usually turns outward at both ends, but in some instances it crosses the division

line, becoming attached at both ends to the veins of the corium. From this accessory membrane-vein the discontinuous independents, having reëstablished themselves, proceed to the margin.

The hind wings are unlike anything in other orders. The venation is simple and not particularly difficult to interpret. The primary is strong and on or near the margin. A little beyond the middle it makes a bend and is thickened or gives off a spur-like branch toward the tip. Just behind this line there is a wrinkle corresponding to the anterior longitudinal line of the front wing. There are two independents fused together at the middle, and connected to the primary by a cross vein in most cases. The posterior of these two independents unites at the tip with an accessory vein along the first fold. Between this fold and the next there are two of these accessory veins, which unite with each other toward the base, and are sometimes connected by a cross vein. Still behind this is a forked first posterior and, finally, a single second posterior.

Redtenbacher is the only one who has attempted to trace the homologies of the veins in this group, and I differ from him here, as in Orthoptera, and for the same reason. He believes that the vein VII should lie before the anal field in the front wings. The basal attachments of the veins show that his interpretation is not correct.

HOMOPTERA.

If one excludes the Phytophthires, this group becomes fairly uniform in the character of its venation. The front wings vary from a condition in which both pairs of wings are equally transparent, as in *Cicada*, to one in which they are leathery and nearly opaque; but never to a stage where the course of the veins can not be made out with certainty. There is much difference between the venations of the two pairs of wings, making it difficult at times to homologize the veins.

The family Cicadidæ forms the most distinct group of the Homoptera. The venation is shown in Fig. 59. The most curious feature of this venation is a mark (dotted line, Fig. 59) extending across the wing, which can be seen only in certain lights upon the membrane: but wherever this line crosses a vein, it is very evident, because the vein is here entirely interrupted. There seems to be no other explanation of this line

than that it is a vestige of the line which, in the Heteroptera, separates the corium from the membrane. In this connection a similar structure in the fossil *Fulgorina* is, as already pointed out, of interest. It is possible that these insects, instead of representing the most primitive condition among the Rhyn-

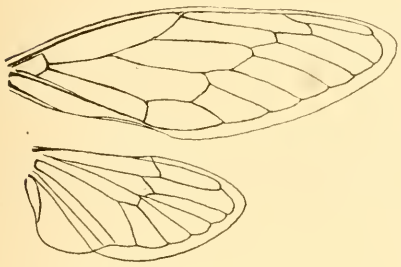

FIG. 59. Wings of *Cicada tibicen.*

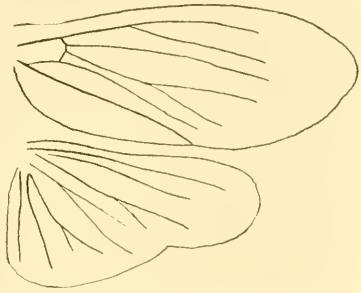

FIG. 60. Diagram of the venation of *Fulgora lanternaria.* The reticulations and finer branches are omitted.

chota, are in fact derived from an ancient ancestor resembling the Heteroptera in the structure of the wings. If *Eugerion* represents the primitive shape of head in this group of insects, it is certain that the primitive shape is more nearly realized in the Heteroptera than in the Homoptera, the latter standing intermediate between Heteroptera and the Phytophthires.

The front wings of the Homoptera always possess a very distinct clavus and are adapted to the body in exactly the same way as in the Heteroptera. In the Cicadidæ, where the wings are not elytral organs, there is still to be seen this adaptation in the long wing-groove in the notum, already described and shown in Fig. 12. This is certainly confirmatory of the idea of the Heteropteral origin of all Rhynchota. The Homoptera may, nevertheless, still retain the venation most like the primitive ancestral form; for the more completely a wing remains membranous, the better may one expect the venation to be preserved.

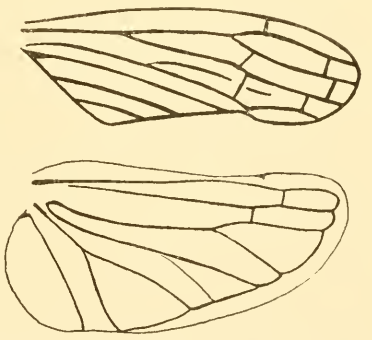

FIG. 61. Venation of *Typhlocyba comes.*

The hind wings are never as peculiar as those of the Heteroptera, but resemble quite closely the front wings. Nevertheless, one can readily trace in the hind wing of Fulgoridæ, which clearly represent the most primitive group among the Homoptera, all the veins of a heteropterous wing. We may conclude, therefore, that the hind wing of most of the families of Homoptera have more nearly kept pace with the front wings in their specialization than have those of the Heteroptera.

In the matter of the homology between the front and hind wing, Comstock and Needham have clearly made a mistake. There are three less cells in the hind wing of *Cicada* than in the front wing, and the missing three are the apical ones. These authors and Redtenbacher place their vein VII one vein too far forward, as they have consistently done throughout this order and in the Orthoptera.

PHYTOPHTHIRES.

The four families constituting this group possess very simple venations, which are quite different in the several families. In only the Psyllidæ is the venation extensive enough to show clearly their affinity to the higher Homoptera. The small size of all these insects is probably accountable for the simplicity of their venation.

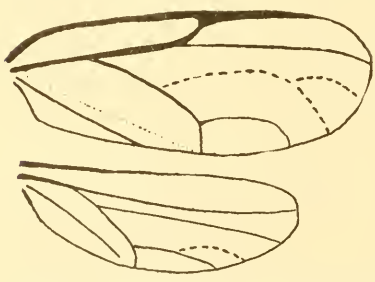

FIG. 62. Diagram of the venation of the Psyllidæ. Fine dotted line is the claval fold; the other dotted lines represent veins that are sometimes absent.

The venation in the Psyllidæ is shown in Fig. 62. The largest part of the area of the wing is occupied by the independents, which appear as a twice-forked branch from the primary. The marginal extends all around the wing and there is but one posterior.

The Aphidæ differ from the Psyllidæ by the suppression of the posteriors, and by some differences in the attachments of the independents, as shown in the accompanying diagram (Fig. 63). The hind wing is more reduced than in the Psyllidæ, and its maximum venation is nearly the same as the minimum of the front wing. The additional independent and the cross vein at the tip are very rarely present.

The Aleurodidæ exhibit a still further reduction. The front

wing is the same in its maximum condition of venation as the maximum of the hind wing of Aphidæ, and the hind wing the same as its minimum. (See Fig. 64.)

The Coccidæ have the hind wing almost suppressed, and the

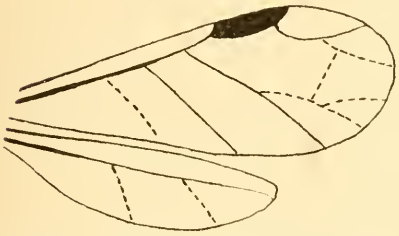

FIG. 63. Diagram of the venation of the Aphidæ. Dotted lines represent veins that are sometimes absent.

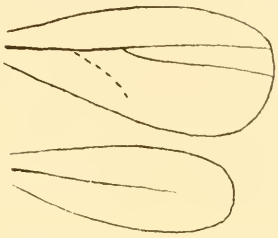

FIG. 64. Diagram of the venation of the Aleurodidæ. Dotted lines indicate veins that are sometimes absent.

venation of the front wing the same as the minimum of the front wing of Aleurodidæ. (See Fig. 65.)

The venation of the Phytophthires has a nomenclature of its own, not relating it to any other groups, the only investigator who has attempted to homologize the veins being Redtenbacher. This author admits only two branches as belonging to vein V (corresponding to my independents) in the Psyllidæ, and sees none at all in the Aphidæ. The posterior he considers to be vein IX, apparently on the ground that the fold represented by the fine dotted line is uniformly considered as vein VIII. The unsoundness of this view has already been shown.

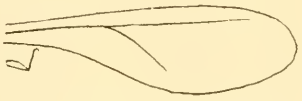

FIG. 65. Venation of the Coccidæ.

PHYSOPODA.

The thrips are uniformly small insects with very simple venation. Both pairs of wings are narrow and fringed with long hairs, as is not uncommon in very small insects. The function of these hairs is to extend the amount of available wing surface, since they are close enough together not to comb the air, but to press upon it as though forming a flat membrane. Such an arrangement would be an impossibility in a larger wing. Hairs beyond a certain length would not be stiff enough. The fringe that exists on the wings of some of the higher insects may be nearly, or quite, as wide as in the thrips,

but they are so small as compared with the width of the wing that they are a very unimportant addition to the effective width.

The front wing is generally distinctly wider than the hind wing, and when this is the case, the venation of the latter is very much simpler. The general character of the venation is shown in Fig. 66. No one has before attempted to homologize the veins, because the venation was so simple that it could not be made to fit into the complex schemes of venation of previous investigators. According to the scheme here proposed, there is no difficulty in the matter. We see the marginal, the primary, a posterior, and an independent. The latter, with the cross veins being often wanting.

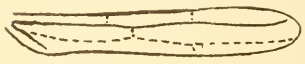

FIG. 66. Diagram of the venation of the Physopoda. Dotted lines indicate veins that may be absent.

COLEOPTERA.

The front wings in Coleoptera are so completely transformed into protective coverings for the hind pair, that their venation is almost indistinguishable. The hind wings possess veins of two types, usually quite distinct. Those near the base are cylindrical, and resemble the veins of more typical wings, while those toward the tip are usually solid for the most part, and tend to fade out around their edges so as to become very indefinite in shape. These are usually not treated as veins, but we have previously shown that they are not essentially different from undoubted veins. In this case they are certainly not to be homologized with any veins in other orders, in spite of their essentially identical structure.

The most characteristic thing about the hind wing in this order is the manner of folding. These wings exhibit a good deal of variation in this respect, but there is one point in which they all agree, if the wing folds transversely at all—abortive wings, or those not fully covered by the elytra, lose the characteristic fold that occurs in all normal wings. This common character is the dividing of the area between the two strong divergent veins—the primary and the first posterior—into four triangular areas by the lines of folding. These triangles may be seen in Figs. 67–70. Besides these, there is always one, and sometimes two, basal folds, and there are also extremely

variable apical folds. In Fig. 67 the veins show very distinctly the lines of folding for a double basal fold, but in this case the wing is folded only once. The breaks in the veins in this case are doubtless vestigial.

The method of folding is as follows: The largest white area, the third coming from the front margin near the base, is the only one that remains uncovered. All the adjacent areas bend under it. The area in which the primary vein lies is thus brought partly beneath this area. The two small triangles

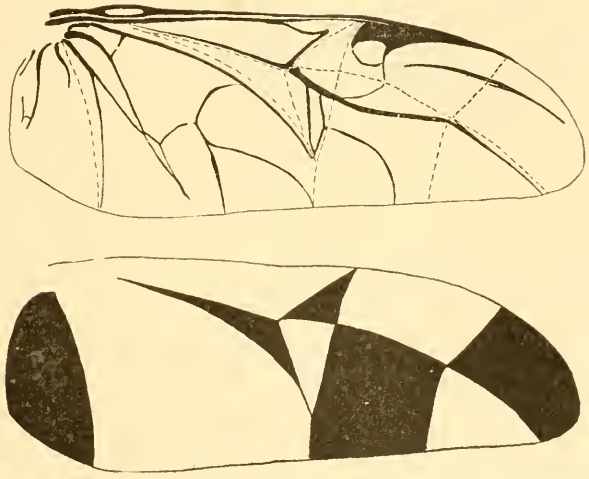

FIG. 67. Venation and folding of *Harpalus caliginosis*. Dotted lines indicate lines of folding; black areas those that are reversed in folding.

also fold so as to lie partly over the primary vein. The tip of the wing beyond the triangles folds first longitudinally along a slight curve, which causes the extreme tip to fold back upon the more basal portion. The folding is brought about by the approximation of the tips of the primary and the first posterior by their own elasticity, and the extension of the wing by a pull on the anterior marginal by the extensor muscle.

In the form represented in Fig. 68 the same method of folding occurs for all but the anal area, where there is one more complete fold. In this wing, as in the one previously considered, the area (white) containing the first posterior vein is uppermost when the wing is folded, all the adjacent areas being doubled beneath it. The most striking feature of this wing is the arrangement of the veins whereby this third area is carried

forward, as contrasted with the wing previously studied. Another type of folding, as seen in *Dermestes* and other beetles with rather short wings, is shown in Fig. 69. This can be compared, area for area, with the wing last considered, but the result is a single rather than a double folding of the apical region. These three types of folding may be considered as representing three stages in the development of a complicated folding, such as is found in the long-winged forms, the fundamental, or short-winged, type being represented by *Dermestes*, and the culminating stage being seen in *Staphylinus*.

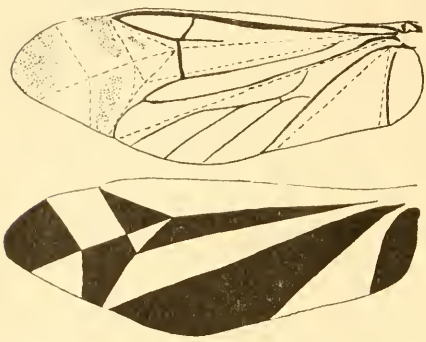

FIG. 68. Diagram of the venation and folding of a beetle with double basal fold. Dotted lines are lines of folding; black areas those reversed in folding.

The Staphylinid type is illustrated in Fig. 70. Here there are three transverse folds and several added longitudinal folds in the apical region of the wing. The method of inserting a longitudinal fold is clearly indicated in the diagram. The carrying of the basal transverse fold across the anal region is another feature in which this insect is peculiar.

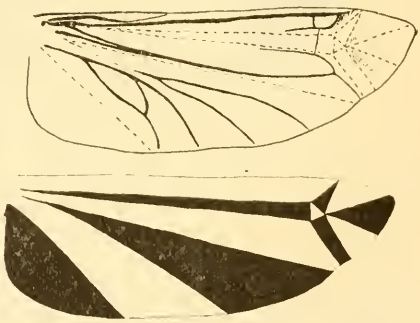

FIG. 69. Diagram of venation and folding in *Dermestes lardarius*. Dotted lines indicate folds; black areas those reversed in folding.

The venation of beetles, as will be seen in these illustrations, consists of two distinct types, as was first pointed out by the author (Woodworth, '89). One is seen in Fig. 67, the other in Figs. 68–70. In the former, there is a cross vein beyond the first transverse, and the whole venation about the fold is unique.

The most conspicuous elements of a beetle's venation are the primary and the first posterior; between them there are two independents. Basal to the fold, one or both of these may

become connected with the principal veins, and they appear often as recurrent branches. Beyond the fold the veins are broad, flat, and solid. There are also two independents between the first and second posteriors. These are often more or less fused and are generally connected to the adjacent veins by long cross veins. The second posterior is generally double and branching, with one or two cross veins. Behind the second there is at least one other posterior vein.

Redtenbacher, and Comstock and Needham ('98–99, p. 561 *ff*) have overlooked the independents in front of the first posterior, and have located vein VII (=Cu) on the independents behind this vein. In this they are certainly wrong. None of them have advanced any convincing argument in support of their identification. *Atractocerus* is an aberrant rather than a primitive member of this order, but there is nothing in its venation that would lead to the conclusion that the veins have the homologies assigned to them by these authors, and the data in reference to tracheation are, to say the least, conflicting. The evident character and position of the veins certainly conform to the other interpretation.

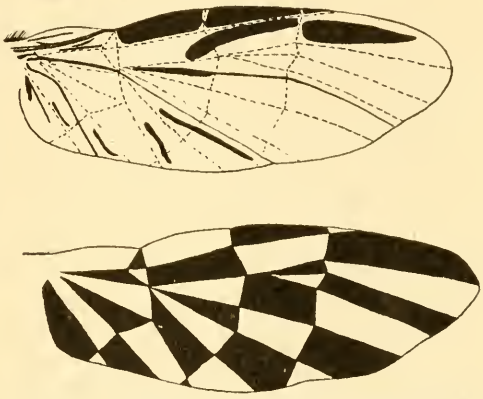

FIG. 70. Venation and folding of *Staphylinus cinnoptarous*. Dotted lines indicate folds; black areas are those reversed in folding.

NEOPTERA.

The Diptera, Hymenoptera, and Lepidoptera, which constitute this group, have been supposed by many investigators to form a single natural super-order, but the transition stages connecting these orders are difficult to conceive of without going back to their neuropterous ancestors. They are the only large groups, unless it be the Coleoptera, that were entirely absent in the Paleozoic era. In all other cases there were species present that possessed enough of the characteristics of existing orders to make their recognition quite easy.

There is but little similarity between the venation of the wings of these three groups. The venation in each case is represented by only a few veins; all the cross veins present are specialized, and almost as constant and important as the longitudinal veins. This cross-vein specialization is the keynote of the venations of the Neoptera.

DIPTERA.

The higher flies possess a venation which is very characteristic and uniform. In no group is there as large a number of species with so little variation in their vein arrangement as is true in the higher families of flies. The lower flies present abundance of variation in venation, so that at times it is rather difficult to carry out homologies with them.

The character which at once sharply separates the flies from all other insects is the special modification of the hind wing into an organ only remotely associated with flight. This requires a somewhat different development of the front wing to suit it for independent action. In other orders, where the hind wings are greatly reduced, there is still some connection between the two wings. In the mayflies, for example, either the reduced hind wing overlaps the base of the front wing, or, in case it is so narrow that it would too readily slip off, there has been developed a hook-like structure that holds the wings together in much the same way as occurs in all Hymenoptera. In the males of scale insects the hind wings are minute and rod-like, but here, again, they are hooked to the front wings.

In conformity with the peculiarities of Diptera just pointed out, the venation exhibits a character in the hind areas which contrasts strongly with that found in any front wing, except in those Neuroptera where the wings remain somewhat independent; but in these cases the resemblance is evidently not a true homology. In the Sialidæ and other related neuropterous insects, in the posterior region of the wing are three veins that arise from a common center and are bound together by cross veins, producing basal cells in the manner so common in Diptera, but every other indication is to the effect that the veins inclosing the basal cells in Diptera lie in front of those surrounding similar cells in the Neuroptera. We doubtless have here analogous structures produced by similar mechanical needs.

The families in which the largest number of veins occur are the Tipulidæ and the Psychodidæ; the smallest number is found in the Cecidomyidæ. These three families are all closely related, and the group to which they belong is, by general consent, placed at the lower end of the series.

The Cecidomyidæ are very closely related to the Mycetophilidæ. The venation of both families is shown in Fig. 71. With the exception of the vein marked CM, which may disappear in both families, the maximum venation in Cecidomyidæ is exactly the same as the minimum venation in Mycetophilidæ. As far as the venation is concerned, the two families may be considered as representing degrees of development along exactly the same line, the Mycetophilidæ furnishing the transition from the simplest condition, that of the Cecidomyidæ, to one complex enough to make easy comparison with the minimum condition of the Tipulidæ.

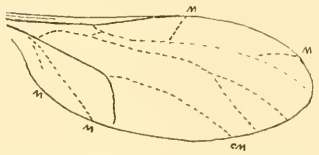

FIG. 71. Diagram representing the venation in Cecidomyidæ and Mycetophilidæ. Solid lines represent constants in Cecidomyidæ; line CM is variable in both families; lines M are variable in Mycetophilidæ, and entirely absent in Cecidomyidæ; the other dotted lines are constant in Mycetophilidæ and variable in Cecidomyidæ.

The Tipulidæ are a large and quite varied group. The veins are not particularly difficult to homologize, but their homology is often disguised by the relative position of the forkings, which results in a series of patterns so different in general appearance that the venation seems at first sight not to be comparable. Fig. 72 shows the variation within the group. The venation of Tipulidæ is easily comparable with most of the types of fly venation, and may be considered as representing, if not the primitive, at least the normal venation of Diptera and the most available type for comparison and the determination of homologies.

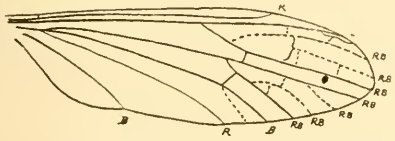

FIG. 72. Diagram of the venation of Tipulidæ. Solid lines represent constants, dotted lines variables. Brackets show varying attachment at veins. B, indicates concave veins, according to Adolph; R, convex veins; RB, veins considered by that author as concave in some species and convex in others.

The Dexidæ constitute a very small family most closely allied to the Tipulidæ. The venation is given in Fig. 73, but shows nothing particularly significant.

The Psychodidæ are minute flies rather isolated from other families. The venation is shown in Fig. 74.

The Culicidæ, Chironomidæ, and Blepharoceridæ constitute a group with very little difference in venation; they are the

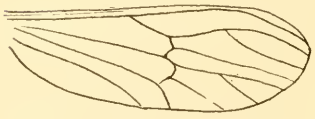

FIG. 73. Venation of the Dexidæ.

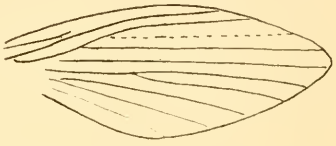

FIG. 74. Venation of the Psychodidæ. Dotted line shows vein which is often absent.

nearest allies to the Psychodidæ, their wings being somewhat intermediate between the venation of that family and the normal type. (See Fig. 75.)

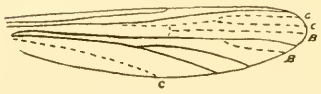

FIG. 75. Diagram of venation of Culicidæ, Chironomidæ, and Blepharoceridæ. Minimum venation is that of Chironomidæ; adding veins marked B gives venation of Blepharoceridæ. The maximum venation is that of Culicidæ.

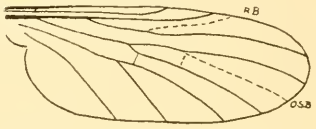

FIG. 76. Diagram of venation of higher Nematocera. Maximum is found in Rhyphidæ; minimum in Orphnephilidæ; Bibionidæ and Simulidæ are intermediate. Letters at end of dotted lines indicate families in which these veins are variable.

The higher Nematocera exhibit but little variation in actual venation, but vary greatly in the arrangement and relative strength of the veins. The Bibionidæ vary most in the former

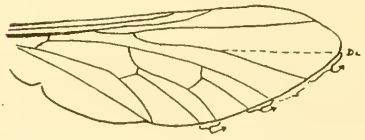

FIG. 77. Diagram of venation of Brachycera. Vein marked DC is wanting in Dolichopodidæ and Lonchopteridæ. Brackets indicate tendency of union of tips, and arrows direction of shifting.

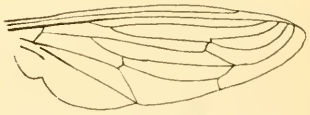

FIG. 78. Wing of *Midas*, showing extreme of fusion and shifting. In this case two anterior pair of veins have become entirely fused.

particular, and in the Simulidæ the independents and the veins in front of them are strong, while the rest are reduced to scarcely more than wrinkles of the membrane. (See Fig. 76.)

The Brachycera (Fig. 77) have a very uniform venation, but several groups exhibit an evident tendency toward the

fusion of the tips of certain veins and the shifting of the united tips forward. These tendencies are responsible for whatever difficulty there may be in the interpretation of the venations. The figure of *Midas* (Fig. 78), which is an extreme case, shows the effect of such modification on the general appearance of the venation.

The Cyclorapha are the most uniform of all the groups in the matter of venation. The accompanying figure of the venation of the house fly (Fig. 79) indicates the character of this venation. The only variation of much significance is the weakening, or entire suppression, of one or more of the posterior veins, or the posterior cross veins, in the smaller species. This reduction process is carried to the extreme in the Phoridæ. In no case is there any difficulty in recognizing the character of the remaining veins.

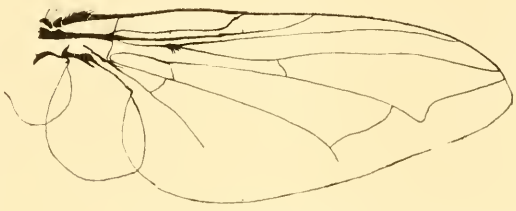

FIG. 79. Wing of a house fly.

The Pupiparia possess a venation which is evidently of the same type as that of the last group. It lacks the cross veins, but does not differ greatly from the wings of the Orthorapha that have undergone this reduction. As far as the wings indicate, there is little ground for making the Pupiparia a group of as high rank as is usually done.

There are three principal schemes of nomenclature for the dipterous wing. One of these is that of the systematists, in which the evident strong veins of an Orthoraphid wing are numbered, from in front backward, first longitudinal, second, etc. In the lower groups this is quite consistently followed, the additional veins being usually treated as branches or as added veins. In the reduced venation of the Cecidomyidæ a mistake was early made in the attempt at homologizing the veins, and this error, though recognized, was held to for sake of uniformity within the family. The terms, therefore, do not have the same significance in that group as elsewhere.

The scheme proposed by Adolph, and followed by Redtenbacher, is the most elaborate attempt yet made to bring the Diptera into line with other orders in vein nomenclature.

Adolph's scheme of the dipterous wing includes not less than twenty-two alternating convex and concave veins, which, with the exception of a number of veins at the two ends of the series, includes a concave and convex vein for every vein actually existing in the vein of one of these insects. In Fig. 72 it is shown that in a single family every one of the independents has been treated in one species as convex and in another as concave. According to this author, as has already been explained, there is a fundamental difference between a convex and a concave vein; consequently, veins that have been supposed to be the same in two insects are actually different, if in one case they are a little above the average level of the membranes and in the other below it. If this were true, the whole nomenclature of the systematist would be wrong.

The third system was worked out by Comstock and Comstock ('95) and agrees in nearly every particular with that adopted here, except in the terms used as names for the veins, and in other slight differences dependent upon our different conceptions of insect venation. This system does no violence to the ideas of systematists, whose knowledge of the comparative anatomy of this organ is certainly not to be despised.

HYMENOPTERA.

The venation of the Hymenoptera exhibits a remarkable degree of uniformity. From the sawflies at one extreme to the bees at the other, we find only a single type of arrangement. Such variation as occurs is all in the nature of reductions from the typical venation. It is usually found associated with small size, and is most prevalent among the parasitic wasps.

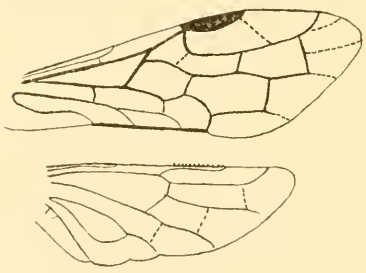

FIG. 80. Diagram illustrating the venation of the Tenthredinidæ. Dotted lines show variable veins.

While within the order the problems of homology are relatively easy, this is not true when we attempt to compare this venation with those of other groups. As none of the other higher orders approximates closely in venation that of the Hymenoptera, there is ample ground for difference of opinion. I am compelled to take a

positive position very distinctly opposed to the latest study on this subject, that of Comstock.

The uniformity of structure makes it quite immaterial where we begin the study of this venation. The order contains no families with anything that may be called an ancestral venation connecting it in any peculiar manner with another group, or showing how the peculiar venation of this order has arisen. The only unusual forms are the reduced venations found in several families, and the slightly increased venation of the Tenthredinidæ (Fig. 80). This group has been considered the lowest in the series. Here, therefore, rather than in the groups with reduced venation, may we hope to find suggestions on the phylogeny of this venation type.

The Tenthredinidæ and Siricidæ (Fig. 81) differ from all other members of the order in the possession of an additional

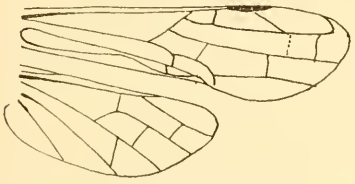

FIG. 81. Diagram of a Siricid wing. Dotted line shows variable cross vein.

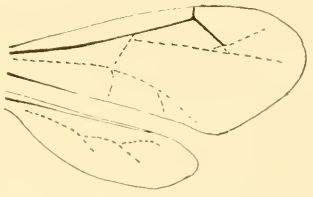

FIG. 82. Venation of the Cynipidæ. Dotted lines are veins which may be suppressed.

posterior vein in the front wing, there never being more than the merest rudiment of it in other families. They also sometimes possess additional cross veins, one in the neighborhood of the stigma in the front wings, and a couple near the tip in the hind wings; very rarely there is an additional independent at the tip of the front wing.

The parasitic forms show the extreme in the reduction of the venation, where the only vein remaining may be the primary. From this all conditions may be found up to the almost complete venation of the larger Ichneumonidæ. The Cynipidæ (Fig. 82) are peculiar in the great distance between the primary and the margin, which is even more than is shown in Fig. 82; when it alone is present, the appearance is very misleading. The Proctotrupidæ (Fig. 83) show best the range of venation among this series of families. The Ichneumonidæ (Fig. 84) show the suppression of the basal end of the anterior independent. The Pelecinidæ (Fig. 85) show a remarkable approach

toward the venation found in the wings of ants. The suppression of veins in both the Pelicinidæ and Formicidæ is associated with large size and is, therefore, to be considered of

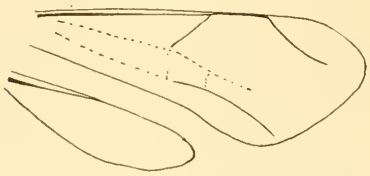

FIG. 83. Venation of Proctotrupidæ. Dotted lines show veins liable to suppression.

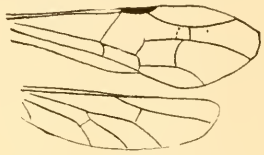

FIG. 84. Diagram of the venation of Ichneumonidæ. Dotted cross vein sometimes wanting.

a different kind from that in the smaller parasites. The Evaniidæ (Fig. 86) and Brachonidæ (Fig. 87) both have reduced venations, the latter family to an extreme degree.

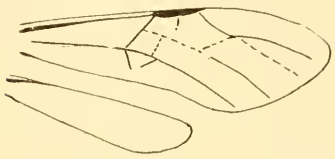

FIG. 85. Diagram of the venation of Pelicinidæ. Dotted lines indicate veins sometimes absent.

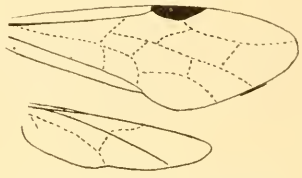

FIG. 86. Diagram of the venation of Evaniidæ. Veins sometimes absent indicated by dotted lines.

The ants (Fig. 88) possess as distinct a venation as any group of Hymenoptera, having no close neighbors, unless the resemblance in Pelicinidæ proves to be more than superficial.

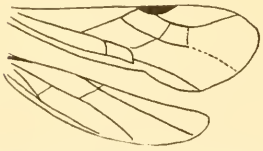

FIG. 87. Diagram of venation of Brachonidæ. Dotted tip of vein often suppressed.

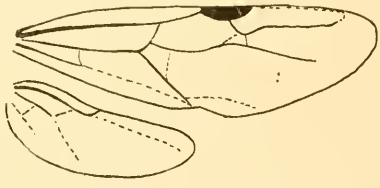

FIG. 88. Diagram of venation of Formicidæ. Dotted lines indicate veins that may be wanting.

Among the wasps, the most significant venations are seen in Pemphredonidæ (Fig. 89), Crabronidæ (Fig. 90), and Scoliidæ (Fig. 91). In the higher wasps and bees the variation is only slight, and consists in the suppression of one or two cross veins and the ends of the longitudinals.

It will thus be seen that there is not a great deal of diversity in the Hymenoptera, and that what there is consists of the simplest type of reduction.

The comparison of the front and hind wings is not very difficult, on account of the many reduced front wings that

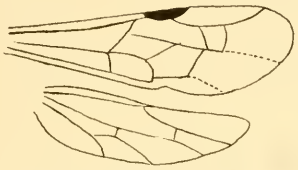

FIG. 89. Diagram of venation of Pemphredonidæ. Dotted tips of veins often wanting.

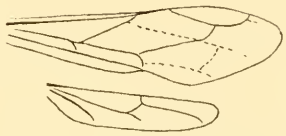

FIG. 90. Diagram of venation of Crabronidæ. Dotted veins often absent.

approach the normal venation of the hind wings. The comparison with other orders is a much more difficult matter. The nomenclature in common use among systematists is peculiar, and is not claimed to indicate necessarily relationships with other orders. Redtenbacher considers the vein V of his system to be represented by the spur shown only in the figure of Tenthredinidæ. Comstock applies the corresponding term media to the outer portion of Redtenbacher's vein VII, while I would apply the term to all of Redtenbacher's vein VII and to Comstock's veins V and VII. Redtenbacher does not attempt to name cross veins, but Comstock identifies most of the veins that have the appearance of cross veins as being in fact longitudinal veins, or their branches, that in this venation assume positions distinguishing their nature. The only ground for this interpretation appears to have been the author's unbounded faith in a venation scheme that has a definite number of branches to each vein. I believe he has done violence to the facts in attempt-

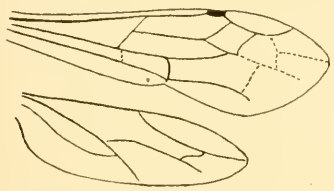

FIG. 91. Diagram of venation of Scoliidæ. Dotted tips of veins and cross veins may be absent.

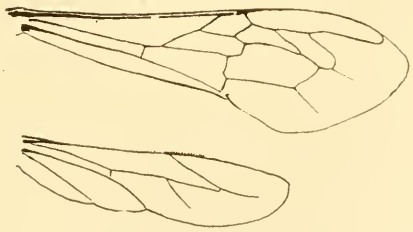

FIG. 92. Venation of *Apis*.

ing to overthrow the conceptions in regard to the nature of the elements of this venation which have stood the test of practical use in the system of nomenclature adopted by the systematists.

If the suggestion made, when considering the venation of the Phryganæidæ, in reference to the ancestry of this group, is to be given any weight; if the homologies I have indicated, which were determined on purely anatomical grounds, are to be given any weight, they will entirely support the system of nomenclature here proposed. In most schemes of classification the Hymenoptera are placed nearer the Diptera than to the Lepidoptera. The structure, however, really supports the suggestion of relationship shown by the resemblance of the larvæ of sawflies and those of moths. These two orders are the youngest groups, since the Diptera are shown by the geological record to be distinctly older. The suggestion of Phryganæid origin is a very attractive one, for if the figure of the fore wing of Chloropsyche is compared with that of the Hymenoptera, the veins supposed to be suppressed will, in each case, correspond with irregularities in the course of veins not otherwise easily accounted for. Thus there is a vestigial structure shown in many Hymenoptera, indicating the suppression of a longitudinal vein in the median and first two discoidal cells, and the lanceolate cell in sawflies suggests the lacking posterior veins. If all these are added and the third transverse cubital and second recurrent suppressed and each longitudinal vein forked, we have exactly the venation of the front wing of Chloropsyche. The hind wing of Helicopsyche corresponds very closely with the venation of the hind wing of a sawfly.

LEPIDOPTERA.

Throughout the greater part of the Lepidoptera the venation is remarkably uniform. The wings are notably free from cross veins, and the number of longitudinal veins is small, even though some of the insects in this order are very large, the largest of any existing insects. Increase in size in this order evidently does not have any necessary influence on the venation. Extremely small members of the order, however, often exhibit decided decrease in the number of veins, giving us the only types that cause any trouble in determining the homologies.

To Comstock we are indebted for the fullest study of the venation of the Macro-lepidoptera, and to Spuler for the only extensive comparative study of the Micro-lepidoptera. These two authors are in essential agreement as to the homology of the veins within the order, but they differ in regard to nomenclature and in the comparisons they institute with other insects. There is a decided difference between the opinion of these later writers and the older views held by the systematists as to the relation between veins, though not in the determination of homologies.

Spuler considers *Micropteryx* as representing the most primitive existing condition of venation, but Comstock supposes it to be *Hepialis*. These two venations are really very similar,

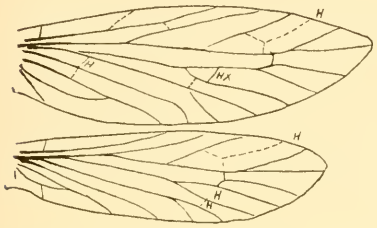

FIG. 93. Diagram illustrating the venation of the Jugatæ. Solid lines show constants in Macropterygidæ, dotted lines the variables. The venation in Hepialidæ is like the minimum venation of Macropterygidæ with the veins marked H in addition. Vein marked HX occurs only in Hepialidæ.

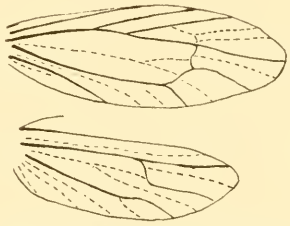

FIG. 94. Diagram of the venation of Tineina. Solid lines are constants, and dotted lines variables.

as will be seen by examining the accompanying diagram (Fig. 93). In *Hepialis* the front and hind wings are a little more nearly alike and the resemblance to the venation of the Phryganæidæ a little more complete, so that we must agree with Comstock in regarding this the more primitive form.

The resemblance of the venation of these insects to that of the Phryganæidæ is so perfect that there seems to be but little doubt that there is a very close relationship between the two groups. This idea is strengthened by the fact that in reduced venations, such as occur in the Tineina, we see the same method of reduction exhibited as that seen in the Phryganæidæ. (Compare Figs. 49 and 94.) If our determination of the veins is right in the latter group, there will be no difficulty in establishing the homologies in this case.

One vein at the end of the discal cell has long been recognized

as being different from a simple branch, and early received the name "discoidal vein," or the more suggestive one, "independent," which we have chosen as a common name for all similar veins. Redtenbacher called this vein and the one in front of it vein V. Spuler added the vein behind, making three, which he denominated vein III. Comstock agrees in this point, but uses the Redtenbacher number V, and also calls the vein media; with this idea I also concur, but substitute, however, the name independent for these veins.

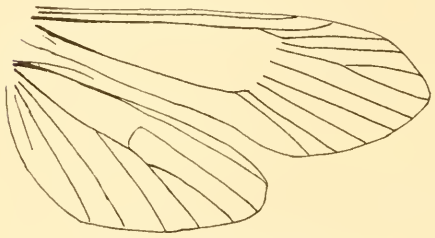

FIG. 95. Venation of Sesiidæ.

Just behind the first posterior vein (vein IV of Spuler, VII of Redtenbacher and Comstock, the one usually called media) is vein V of Spuler, or VIII of Redtenbacher, which is usually represented by only a fold. I consider this an independent vein. These two are the only important points on which there is a difference of opinion.

The accompanying diagram (Fig. 94) shows the extent of the reductions that occur in the smallest moths, the Tineina. Only one independent in both wings is constant, and in the hind wings, when very greatly narrowed, all the veins and branches may be suppressed. The variation presents no unexpected features.

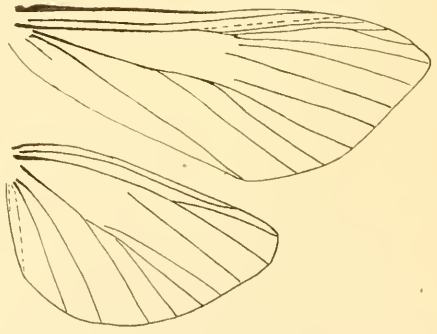

FIG. 96. Venation of the Pyralidina. Dotted line is a variable vein.

Other small moths are represented by the diagrams of the Sesiidæ (Fig. 95), Pyralidina (Fig. 96), and the Tortricidæ (Fig. 97), all of which are remarkably uniform in contrast to the Tineina. The suppression of the basal portion of the independents indicates that they are really quite differentiated.

The groups that come closest to Hepialis and Micropteryx,

aside from the Tineina, are the Cossidæ, Psychidæ, and related Bombycoid moths. These are the ones separated by Comstock

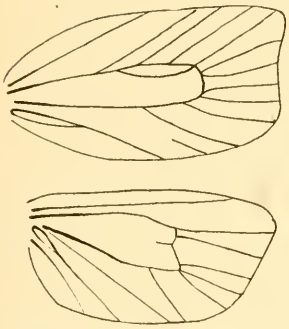

FIG. 97. Venation of the Tortricidæ.

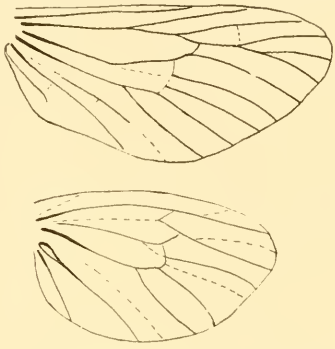

FIG. 98. Diagram of the venation of the Cossidæ and other Bombycoid moths, in which the independent crosses the discal cell.

as the "Generalized Frenatæ." The venation of these is shown in Fig. 98.

The variation in the higher moths and in the butterflies, as

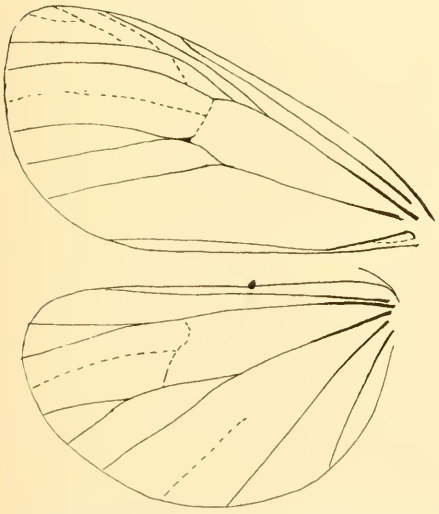

FIG. 99. Diagram of the venation of the higher moths. Dotted lines are variable veins.

FIG. 100. Venation of butterflies. Dotted lines indicate variable veins.

shown in Figs. 99 and 100, is very slight. A great many families and minor groups can be distinguished in their vena-

tion by such characters as the relative length of parts, position of forks, etc. Such questions, however, are beyond the scope of the present paper.

Table of Comparative Nomenclature.

Semper et al.	Redtenbacher.	Spuler.	Comstock.	The Author.
	I		I-Costa	Anterior Margin
Costal	II	I	II Subcosta	Anterior
Subcostal	III	II	III Radius	Primary
Branches 1	1	1	1	Branch 1
2	2	2	2	2
3	3	3	3	3
4	4	4	4	4
5	5	5	5	5
6	V, 1	III, 1	V, 1 Media	Anterior Independent
Discoidal	V, 2	2	2	Middle Independent
Median	VII			
Branches 1	1	3	3	Posterior Independent
2	2	IV, 1	VII, 1 Cubitus	First Posterior
3	3	2	2	Branch of Posterior
	VIII	V	VIII Anal	Secondary Independent
Submedian	IX	A	X	Second Posterior
Anal	XI	B	XI	Third Posterior

RESUME AND CONCLUDING REMARKS.

The purpose of the foregoing study has been to establish a rational theory of venation. The development of this theory has involved numerous radical departures from the views usually held, not only in regard to the venation itself, but also to the origin of the wing and its effect on the evolution of the thorax. I believe there have been ample grounds for the changes that have been proposed, and all that fit together to make a comprehensive general scheme whereby the nature of venation as a whole, and a host of peculiarities in individual venations before unexplainable, are made clear.

The wings are conceived of as organs whose function is so definite, and the requirements of which are so exacting, that the mechanical necessities are the dominant factors in their first production and in all subsequent specializations. Thus, in the origin of the wing the most important matter was its utility for flight. It was this that was responsible for the location of the wings on a particular region of the insect's body, even for the determination of the part of the segment occupied. A wing could not have been produced in another situation, since flight is dependent upon equilibrium. The shape and structure of the organ are determined by its function, to a predominating extent. There must be a wide, expanded area, coupled with lightness and strength, and the latter must be distributed so as to meet the particular strains to which the wing is to be subjected. The relation to the body must be such as to permit the proper motion of the wing, even though it require the readjustment of the whole thoracic structure—indeed, it is clearly responsible for the most profound change in the structure of the body wall that the segments have experienced. It could also be shown that the internal structures were subjected to a similar readjustment.

In the wing itself, the one specialization of importance for aërial locomotion is the production of the veins. These structures are developed primarily for strength. Any other function is certainly secondary. Their structure when best developed

is that which is mechanically the strongest for the amount of material used, a hollow cylinder, though the veins may become rod-like, or flat, or even disappear in situations where they have become useless. There is no essential difference in either the structure or origin of the different sorts of veins; this indicates that their functional utility is the important reason for their existence. Insects have veins in their wings, primarily because they are serviceable.

The arrangement of veins is in like manner the expression of the mechanical needs of the wing. The venation is conceived of as receiving nothing from the precursor of the wing except veins that were developed in the same way and to meet identical needs with those of the organ after it became adapted to flight. A system of tracheæ that were developed for the purpose of respiration can not, according to this view, have any relation with the veins subsequently developing in order to strengthen the organ, since the functions are incompatible, and since the production of a vein in a tracheal gill would, by just that much, reduce the breathing surface.

The detailed study of the venation of the various groups of insects has only strengthened the idea of the predominating influence of the functional requirements, and confirmed the writer in the view that in this we may find a basis for a true theory of venation. The theory, stated very briefly, is, (1) that each vein is produced for mechanical reasons: the marginals to stiffen the edges of the wing, the primary to serve as the dominant vein, the anterior and posteriors to supplement the primary at the points of greatest need on either side, the systems of independents and cross veins to occupy the areas of the wing remaining poorly provided with longitudinal veins, and, finally, plication veins in the Elytroptera to meet the special requirements at the points of folding; (2) that the production of different types of venation has proceeded along comparatively narrow lines bounded by inflexible physiological requirements, by which the distinctness of the groups has been maintained.

There will be found, therefore, in all venations certain factors in common, and in each group certain features that can not be so strictly compared, because they were produced under conditions where the mechanical requirements were different. To the extent to which these requirements are uniform, and

only to that extent, shall we find the venations comparable. The nomenclature of venation in each group may be to that extent independent. Thus, in the Odonata we may be able to use with entire propriety the term primary vein at the same time that we use it in the Diptera, but it will not do to apply the term triangle, or basal cell, to structures in the two groups interchangeably. This principle has never been clearly recognized by those who would establish a uniform nomenclature. There must be a distinct nomenclature for each group, with only such terms in common as are clearly homologous. How far homologies can be carried will doubtless be for a long

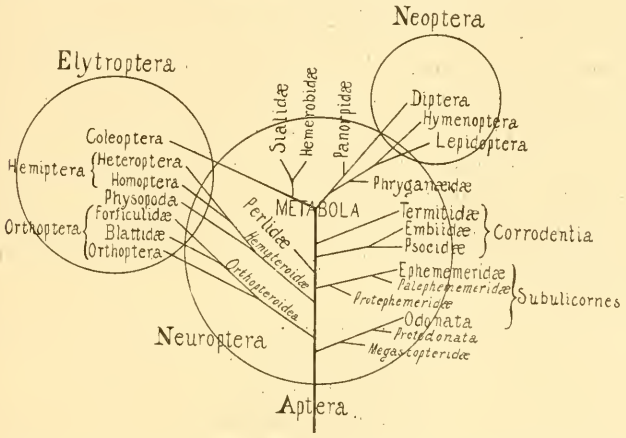

FIG. 101. Diagram illustrating the phylogeny of insects. Extinct groups are omitted, unless definitely leading to existing groups; those given are in italics.

time a disputed point. My own conviction is that strict homology (that is, the use of terms for veins completely comparable) is not possible throughout the whole series of insects, in the case of any vein, not even the primary, because cross veins and independents become, to all intents and purposes, branches of the other veins, and it is not unlikely that true branches often become disconnected, and would then be indistinguishable from independents. It is possible, however, to use terms in a more elastic sense and to speak of the primary with the knowledge that in one case it has branches not strictly comparable with those in the other. The marginal, the primary, the anterior, and the posteriors can, I think, in this sense be used in all the orders of insects, as has been done in the preceding pages. The independents and most of the

cross veins are, as a rule, so diverse that only in allied groups can comparisons be made with any confidence.

The relationship between the groups is more clearly shown by the wings than by any other set of characters. There are a number of cases of parallel development, producing groups that are convenient, though not natural. The *Subulicornes* have two entirely distinct venations, showing the two groups not to be really closely allied, but should have been brought closer together than in the accompanying diagram (Fig. 101). The groups of the Corrodentia are probably not as distinct as indicated on the diagram and possibly should be derived from the same line as the Orthoptera, notwithstanding the absence of ancient fossil remains. The Elytroptera certainly consist of independent groups. The Neoptera are all closely allied to each other, but here, also, the group is probably not monogenetic. While the diagram here given is based on the venation, it is nowhere contrary to evidence obtainable from the study of other characters, and, modified in the manner just indicated, represents the author's views of the phylogeny of the groups of insects. The sequence of the orders should be as follows:

1. Aptera.
2. Neuroptera.
3. Odonata.
4. Ephemerida.
5. Corrodentia.
6. Orthoptera.
7. Hemiptera.
8. Coleoptera.
9. Diptera.
10. Hymenoptera.
11. Lepidoptera.

LITERATURE.

The following works are cited in the text:

Aarons, Frank.

1886. On some new Psocidæ. Proc. Acad. Nat. Sci. Phila., Vol. XXXVIII, pp. 13–18, pl. 1.

Adolph, Ernst.

1870. Ueber Insectenflügel. Nova Acta Leop. Carol. Duetsch. Akad. der Naturf., Bd. XLI, pp. 231–292, tab. 27–32.

1879*a*. Ueber abnorme Zellenbildungen einiger Hymenopterenflügel. *Ibid.*, Bd. XLI, pp. 293–328, tab. 33.

1883. Zur Morphologie der Hymenopterenflügel. *Ibid.*, Bd. XLVI, pp. 41–132, tab. 6.

1885. Die Dipterenflügel, ihr Schema und ihre Ableitung. *Ibid.*, Bd. XLVII, pp. 269–314, tab. 24–27.

Amans, P. C.

1885. Comparaisons des organes du vol dans la série animale. Ann. Sci. Nat. Zool., Tome XIX, pp. 9–222, pl. 1–8.

Audouin, Victor.

1824. Recherches Anatomiques sur le Thorax des Animaux Articules et celui des Insectes Hexapodes en particulier. Ann. Sci. Nat., Ser. 1, Vol. 1, pp. 97–135, 416–432.

Bellesme, J. de.

1879. Sur une fonction de direction dans le vol des insectes. C. R., Tome LXXXIX, pp. 980–983.

Brauer, Friedrich.

1869. Betrachtungen über die Verwandlung der Insekten im Sinne der Descendenz-Theorie. Verhand. zool.-bot. Gesell. Wien, Bd. XIX, pp. 299–318, Taf. 10.

1878. Part II, *ibid.* Bd. XXXVIII, pp. 151–166.

1885. Systematisch-Zoologische Studien. Sitzungsb. d. k. Akad. d. Wissensch. Math.-Naturw. Classe, Bd. XCI, Abth. 1, pp. 237-413, 1 taf.

1886. Ansichten über die paleozoischen Insecten und deren Deutung. Ann. Naturchist. Hofmus. Bd. I, pp. 87–126, Taf. 7–8.

Brauer, Friedrich, und Redtenbacher, Josef.

1888. Ein Beitrag zur Entwicklung des Flügelgeaders der Insecten. Zool. Anz., Jahrg. XI, pp. 443–447.

Brongniart, Charles.

1893. Recherches pour servir à l'histoire des Insectes Fossiles des temps primaires précédées d'une étude sur la nuration des ailes des insectes. Industrie minérale, 3me Série, Tome VII.

Brunner von Wattenwyl, C.

1882. Prodromus der Europaischen Orthopteren. Leipzig, 1882. xxxii+466 pp., 12 pl.

Burmeister, Hermann.

1832. Handbuch der Entomologie. Bd. I, pp. xcvi+108, Taf. 8.

Calvert, Philip P.

1893. Catalogue of the Odonata (Dragonflies) of the vicinity of Philadelphia, with an introduction to the study of this group of insects. Trans. Amer. Ent. Soc. Vol. XX, pp. 152*a-d*, 153-272, pl. 2-3.

Chabrier, J.

1820-22. Essai sur le vol des insectes. Mém. du Mus. d'Hist. Nat., Tome VI, pp. 410-476; Tome VII, pp. 297-372; Tome VIII, pp. 47-99, 349-403.

Comstock, John Henry.

1893. Evolution and Taxonomy. Wilder Quarter Century Book. 114 pp., pl. 1-2.

Comstock, John Henry, and Comstock, Anna Botsford.

1895. A Manual for the Study of Insects. xxxii+702 pp. Ithaca, N. Y., 1895.

Comstock, John Henry, and Needham, James G.

1898-99. The Wings of Insects. Amer. Nat., Vol. XXXII, pp. 43-48, 81-89, 231-257, 335-340, 413-424, 561-565, 769-777, 903-911; Vol. XXXIII, pp. 117-126, 573-582, 845-860.

Dewitz, J.

1878. Beitrag zur Postembryonalen Gleidmassenbildung bei den Insekten. Zeitschr. f. wiss. Zool., Bd. XXX, Suppl., pp. 78-105, Taf. 5.

1890. Einige Beobachtungen betreffend das geschlossene Tracheensystem bei Insektenlarven. Zool. Anz., Jahrg. XIII, pp. 500-504, 525-531.

Eaton, A. E.

1883-88. A Revisional Monograph of Recent Ephemeridæ or Mayflies. Trans. Linn. Soc. Lond., Vol. III, pp. 1-352, pl. 1-6.

Fischer, Leopoldi Henrico.

1853. Orthoptera Europæa. Leipzig, 1853. xx+454 pp., 18 pl.

Ganin, M.

1876. [Materials for a knowledge of the Post-embryonal Development of Insects.] Warsaw, 1876. 76 pp. 4°. (Russian.)

Gegenbaur, Carl.

1870. Grundzüge der Vergleichenden Anatomie. Leipzig, 1870. 2te Auflage. xii+890 pp.

Gonin, J.

1892. Recherches sur la métamorphose des Lepidopteren. Bull. Soc. Vaud. Sci. Nat., Tome XXX, pp. 89-139, pl. 11-15.

Graber, Vitus.

1877. Die Insecten. Theil I., Der Organismus der Insekten. München. vii+404 pp. 16°.

Griffiths, George Charles.

1898. On the Frenulum of the Lepidoptera. Trans. Ent. Soc. Lond., 1898, pp. 121–132, pl. 4.

Haase, Erich.

1891. Zur Entwickelung des Flügelrippen der Schmetterlinge. Zool. Anz., Jahrg. XIV, pp. 116–117.

Hagen, Hermann August.

1870. Ueber rationelle Benennung des Geaders in den Flügeln der Insekten. Stett. Ent. Zeitung, Jahrg. XXXI, pp. 316–320.

1881. The Devonian Insects of New Brunswick. Bull. Mus. Comp. Zool., Vol. VIII, pp. 275–284.

1881. Some Psocina of the United States. Psyche, Vol. III, pp. 195–196, 207–210, 219–223.

1882. [On the Tri-regional Division of the Thoracic Segment.] In Proc. Camb. Ent. Club, Dec. 18, 1882. Psyche, Vol. III, p. 417.

Hampson, George F.

1896. On the Classification of Three Subfamilies of Moths of the Family Pyralidæ: the Epipeschiinæ, Endotrichinæ, and Pyralinæ. Trans. Ent. Soc. Lond., 1896, pp. 451–550.

Kellogg, Vernon L.

1895. The Affinities of the Lepidopterous Wing. Am. Nat., Vol. XXIX, pp. 709–717.

Kempers, K. J. W.

1899-1900. Het adersysteem der Kevervleugels. Tidschrift Entomologie, 42 Deel, pp. 180–199.

Kolbe, Hermann Julius.

1889–93. Einfuhrung in die Kenntnis der Insekten. Berlin, 1889–93, pp. xii + 709.

Lang, A.

1888. Lehrbuch der Vergleichende Anatomie. Jena, pp. iv + 566.

Lendenfeldt, R. von.

1881. Der Flüg der Libellen. Sitzungsb. Akad. Wissensch. Wien. Bd. LXXXIII, Abt. 1, pp. 289-376, Taf. 1–7.

Lowne, B. Thompson.

1890–95. The Anatomy, Physiology, Morphology, and Development of the Blowfly. London, 1890–95. 2 vols. pp. x + viii + 778.

McLachlan, Robert.

1874–80. A Monographic Revision and Synopsis of the Trichoptera of the European Fauna. London, 1874–80. 8°. pp. 523 + ciii.

Marey, C. J.

1869. Mémoire sur le vol des Insectes et des Oiseaux. Ann. Sci. Nat. Zool., 5me sér., Tome XII, pp. 99–100.

Mayer, Alfred Goldsborough.

1896. The Development of the Wing Scales and their Pigment in Butterflies and Moths. Bull. Mus. Coop. Zool., Vol. XXIX, pp. 207–236, pl. 1–7.

Mayr, Gustav L.

1855. Formicina Austriaca. Verh. Zool.-Bot. Gesellsch. Wien, Bd. V, pp. 273–478, Taf. 1.

Meinert, F.

1880. Sur l'homologie des elytres des Coleoptères. Entom. Tidskrift, Bd. I, p. 168.

1880. Sur un organe des Lepidoptères homologue aux balancieurs (haltères) chez les Diptères. Entom. Tidskrift, Bd. I, pp. 168–169.

Meyrick, Edward.

1892. On the Classification of the Geometrina of the European Fauna. Trans. Ent. Soc. Lond., 1892, pp. 53–140, pl. 3.

Müller, Fritz.

1873–75. Beiträge zur Kenntniss der Termiten. Jena Zeitschr., Bd. VII, pp. 333–358, 451–463; Bd. IX, pp. 241–264.

Needham, James G.

1900. Some General Features of the Metamorphosis of the Flag Weevil, *Mononychus vulpeculus* Fabr. Biol. Bull., Vol. I, pp. 179–191.

Packard, Alpheus S., Jr.

1869. Guide to the Study of Insects. Salem, 1869. viii + 702 pp., 11 pl.

1876. A Monograph of the Geometrid Moths or Phalænidæ of the United States. Rept. U. S. Geol. Surv., Vol X, pp. iv + 607, pl. 1–13.

1895. Monograph of the Bombycene Moths of America North of Mexico. Part 1, Notodontidæ. Proc. Nat. Acad. Sci., 1895, pp. v + 390. 49 pl., 10 maps.

1898. A Text-book of Entomology. New York, 1898. xviii + 730 pp.

Paneritius, Paul.

1884. Beiträge zur Kentniss der Flügelentwickelung bei den Insecten. Inaug. Dissertation. Königsberg, 1884. 44 pp., 2 Taf.

Pettigrew, James Bell.

1868. On the Mechanical Appliances by which Flight is attained in the Animal Kingdom. Linn. Trans., Vol. XXVI, pp. 197–277.

1871. On the Physiology of Wings, being an Analysis of the Movements by which Flight is produced in the Insect, Bat, and Bird. Trans. Roy. Soc. Edinburgh, Vol. XXXVI, pp. 321–448.

Plateau, Felix.

1871. Où est ce que l'aile d'un Insecte? Stett. Ent. Zeit., Vol. XXXII, pp. 33–42.

Poleatajeu, H.

1880. Die Flugmuskeln der Lepidopteren und Libelluliden. Zool. Anz., Jahrg. III, pp. 212–213.

Redtenbacher, Josef.

1896. Vergleichende Studien über das Flügelgeader der Insecten. Ann. Naturhist. Hofmus. Bd. I, pp. 153–232, Taf. 9–20.

Rehberg, A.

1886. Ueber die Entwickelung des Insektenflügels. Jahresb. Konig. Gymn. zu Marienwerder fur das Schuljahr, 1885–6, pp. 1–12, 1 Taf.

Riley, Charles Valentine.

1876. Eighth Annual Report on the Noxious, Beneficial, and Other Insects of Missouri, made to the State Board of Agriculture. Jefferson City, Mo., 1876. 185 + iv pp.

Saussure, Henri de.

1868. Etude sur l'aile des Orthoptères. Ann. Sci. Nat. Zool., 5me sér., Tome X, pp. 161-200, pl. 11.

Scudder, Samuel H.

1866. An Inquiry into the Zoölogical Relations of the First Discovered Traces of Fossil Neuropterous Insects in North America, with Remarks on the Difference of Structure on Wings of Living Neuroptera. Mem. Bost. Soc. Nat. Hist., Vol. I, pp. 173-192, pl. 6.

1876. The Mode in which Cockroaches and Earwigs Fold Their Wings. Amer. Nat., Vol. X, pp. 521-529.

1879. Paleozoic Cockroaches; a Complete Revision of the Species of Both Worlds, with an Essay toward their Classification. Mem. Bost. Soc. Nat. Hist., Vol. III, pp. 23-134, pl. 2-6.

1885. Palæodictyoptera; or, The Affinities and Classification of Paleozoic Hexapoda. Mem. Bost. Soc. Nat. Hist., Vol. III, pp. 319-351, pl. 29-32.

1885*a*. Winged Insects from a Paleontological Point of View; or, The Geological History of Insects. Mem. Bost. Soc. Nat. Hist., Vol. III, pp. 353-358.

Selys Longchamps, de E., and Hagen, H. A.

1854. Monographie des Calopterigines. Bruxelles, 1854. 290 pp., 14 pl.

1857. Monographie des Gomphines. Bruxelles, 1857. 460 pp., 23 pl.

Shuckard, W. E.

1836. A Description of the Superior Wing of the Hymenoptera, with a View to give a Fuller and More Certain Development to the Alary System of Jurine. Trans. Ent. Soc. Lond., Vol. I, pp. 208-214, pl. 18.

Speyer, A.

1870. Zur Genealogie der Schmetterlinge. Stett. Ent. Zeit., Jahr. XXXI, pp. 202-223.

Spuler, Arnold.

1892. Zur Phylogenie und Ontogenie des Flügelgeaders der Schmetterlinge. Zeit. f. wiss. zool., Bd. XXXV, pp. 597-646, Taf. 25-26.

Verson, E.

1890. Der Schmetterlingsflügel und die sogenante Imaginalscheibe derselben. Zoöl. Anz., Jahrg. XIII, pp. 116-117.

Viallanes, H.

1882. Recherches sur l'Histologie des Insectes et sur les Phenomenes Histologiques qui Accompagnent le Dévelopement Postembryonnaire de ces Animaux. Ann. Sci. Nat., 1882, Tome XIV, pp. 1-348, pl. 1-4.

Van Rees, J.

1888. Beiträge zur Kenntniss der innern Metamorphose von Musca vomitoria. Zoöl. Jahrb., Bd. III, pp. 1-134.

Walton, L. B.

1900. The Basal Segments of the Hexapod Leg. Amer. Nat., Vol. XXXIV, pp. 267–274.

Weismann, August.

1864. Die Nachembryonal Entwickelung der Musciden nach Beobachtungen an Musca vomitoria und Sarcophaga carnaria. Zeitschr. f. wiss. zool., Bd. XIV, pp. 187–336.

1866. Die Metamorphose der Corethra plumicornis. Zeitschr. f. wiss. zool., Bd. XVI, pp. 45–127.

Westwood, J. P.

1839–40. An Introduction to the Modern Classification of Insects. London, 1839–40. 2 vols. pp. xii+462. xi+587+158.

Winnertz, J.

1863. Beitrag zu einer Monographie der Pilzmücken. Verh. Zool.-Bot. Gesel. zu Wien, Bd. XIII, pp. 637–964, Taf. 18–21.

Wood-Mason, J.

1877. On the Final Stage in the Development of Flight in Holomorphic Insects. Ann. Mag. Nat. Hist., Ser. 4, Vol. XIX, pp. 380–382.

1883. A Contribution to Our Knowledge of the Embiidæ, a Family of Orthopterous Insects. Proc. Zool. Soc. London, 1883, pp. 628–632.

Woodworth, C. W.

1889. [Venation of the Wings of Coleoptera.] In Proc. Camb. Ent. Club. Psyche, Vol. V, p. 282.

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COLLEGE OF AGRICULTURE, AGRICULTURAL EXPERIMENT STATION

ENTOMOLOGY

Vol. I, No. 2, pp. 153-198. October, 1906

CATALOGUE OF THE EPHYDRIDAE, WITH BIBLIOGRAPHY AND DESCRIPTION OF NEW SPECIES.

BY

BURLE J. JONES

SEP 14 1907

SACRAMENTO:
W. W. SHANNON, - - SUPT. STATE PRINTING
1906

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By BURLE J. JONES.

The present paper represents part of the scientific results of the study of the mosquito problem near Burlingame. One of the flies described herein was the most conspicuous inhabitant of many of the mosquito-infested pools. Three species of this family have been hitherto credited to California; ten others are now identified in the University collection, of which four are new.

NEW SPECIES OF CALIFORNIA EPHYDRIDAE.

Notophila varia, n. sp., ♂ and ♀.—The lighter specimens of this species are similar to *N. bellula* Williston, from which they can be distinguished by the brown vitta of the pronotum, the smaller size, and usually the lighter color of the antennæ. The brown spots on the upper part of the mesopleuræ seem also to be lacking here.

Varying from black to dull brown; front yellowish brown, with sometimes a trace of a broad, darker-brown stripe from the orbits on either side at the vertex to the lower edge of the front. The narrow orbits gray. Antennæ yellow, rarely reddish yellow, the upper part of the second and third joints and sometimes the tip of the third joint brownish or blackish.

Face and cheeks yellowish, often grayish directly beneath the eyes. Palpi light yellow; all of the femora except the knees, the lower part of the pleuræ, and the abdomen with close grayish pubescence. In most specimens a black or dark-brown cloud extends from the lower part of the pleuræ on each side upward across the shoulders, thence backward diagonally across the thorax, meeting at the center above, thus leaving a triangular light-brown spot on the pronotum. A reddish-brown vitta crosses this triangular spot from the front backwards, disappearing in the darker cloud behind. The dark color is usually slightly dispersed or entirely wanting on the scutellum; occasionally it crosses the center of the thorax diagonally or is otherwise irregular. Abdomen hoary like the femora, with brownish spots irregularly arranged on the anterior part of each segment, generally leaving the lateral border and a median line above grayish. Tips of femora, upper part of front tibiæ, middle of hind tibiæ and the tarsi, except their tips, yellow; lower part of front tibiæ and their tarsi blackish. Tips of all the tarsi slightly blackish. Wings uniformly a trifle brownish; halteres pale yellow. Face falling off considerably beneath the antennæ for this genus, with a slight median ridge above. Face narrow; entire body slender. Pattern of thoracic macrochætæ and venation of wings normal. Length, 3 to 3.25 mm. Middle and Southern California.

Parydra aurata, n. sp., ♂ and ♀.—Very similar to *Parydra bituberculata,* but differs fundamentally in the absence of the conical warts of the scutellum, also in the absence of brownish dusting on the face, in the lighter color of the antennæ, and the possession of uniform golden pubescence. Entire insect clothed with golden-yellow pubescence, under which it is black, more or less shining, and sometimes with a steel-blue reflection on the abdomen. Epistoma more densely pubescence toward the oral margin; antennæ brown or brownish yellow; tibiæ reddish yellow, sometimes distinctly brownish in the center; tarsi reddish-yellow, last joint brown or black. The characteristic bristle on each side of the face long and slender; a distinct impression above and toward the center of the face from this. Orbits and cheeks broad; clypeus very prominent; epistoma with two broad, very flat transverse ridges crossing the center above the clypeus (these are some-

times almost indistinguishable). Antennal arista long and slender, base pubescent, bare toward the tip. Vittæ of the thorax almost obsolete; the four characteristic rows of thoracic hairs slender, black, strongly reclinate. Wings brown, veins brownish black; a hyaline spot at each side of the broad brownish band of the cross veins, a fifth spot at the base of the marginal cell; second segment of the costa nearly twice as long as the third. Second longitudinal vein without appendage; third and fourth longitudinals with a slight divergence at the tips; fifth longitudinal scarcely attaining the margin of the wing. Length, 3.5 to 4 mm. San Francisco, California.

Ephydra millbrae, n. sp., ♂ and ♀.—Front bronze bluish green with sparse grayish pubescence, epistoma shading from a dark brown above to a light chestnut brown at the oral margin, sides of the face beneath brownish pruinose; antennæ dark brown, first segment lighter; proboscis black above, yellow at apex; palpi light brown; orbits purplish blue immediately beneath and behind the eyes. Thorax from the lateral margins above marked with alternating vittæ, five of blue and four of green, iridescent and sometimes indistinct; body beneath light green, with very fine grayish pubescence; abdomen green, slightly bronzed above; general color of the legs brownish green, trochanters lighter, second pair with a decided yellowish pubescence; upper half of the tibiæ light, with a row of orange yellow hairs on the upper half behind; knees yellowish; wings hyaline, halteres lemon yellow. Front sparsely clothed with short bristles, regularly arranged; ocellar protuberance considerably raised, a pair of stout macrochætæ midway between the lower and two upper ocelli, a lateral row of 2 to 3 fine hairs in the center of the ocellar triangle; a slight depression below the lowest ocellus. Epistoma densely pruinose, a row of bristles on the upper half in front, converging with the oral margins laterally; the entire epistoma clothed sparsely with short hairs, a row of slight bristles fringing the oral margin. Second joint of antennæ with numerous fine hairs, third joint destitute of a lateral pile. Sides of the thorax with only two stout macrochætæ. Veins of wings yellowish at base, darker toward the apices. Pattern of the thoracic macrochætæ above showing distinctly the

generic arrangement as given by Professor Becker in his monograph of this family, *Berliner entomologische Zeitschrift,* 1896, Tafel vii, Fig. 19 (reproduced here in Fig. 105, *b*). The two hairs at the center of the field posterior are so small, however, that they might be overlooked in a casual examination. (Fig. 105.) Length, 3.75 to 4 mm.

Egg.—White obovate, somewhat irregular in outline, without definite markings; clothed with hairs about the smaller end, usually sparsely; attached by the larger ends to floating bits of vegetation or puparia. (Fig. 102.)

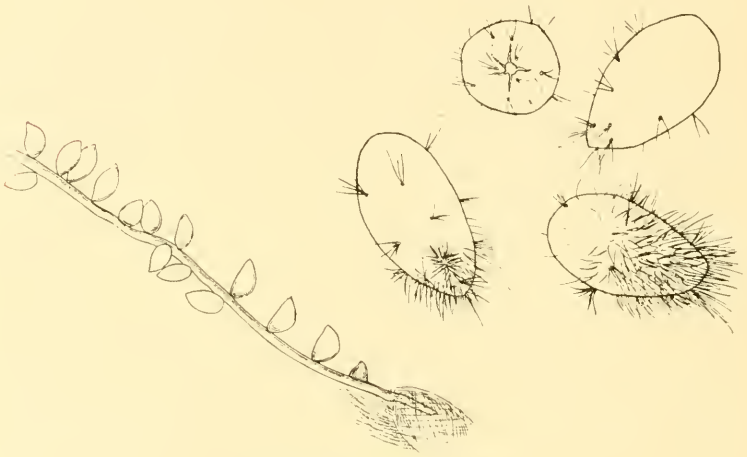

FIG. 102. Eggs of *Ephydra millbrae.*

Larva.—Length, 10 to 12 mm. with the anal siphon and its two tubes extended. Length of siphon, 3.5 mm. Densely and uniformly pubescent, excepting a number of small, very dense clusters of black hairs irregularly arranged on the last six segments, dorsad. Abdominal segments with eight pairs of false legs, non-articulated, ventral exterior end of each with two rows of transverse, curved hooks; all but last pair with first row containing four hooks, second five; behind these are three or four irregularly arranged. Each leg of the last pair bears thirteen claws in three irregular rows, the first two with three claws each and the third with seven smaller ones. Mouth parts composed chiefly of a pair of large median or foot hooks, provided with smaller, hook-like processes on the ventral sur-

face. Antennæ rudimentary, with first lobe comparatively long, second and third short. First segment back of the head with a pair of fan-like spiracles or gills; the number of branches varies from three in the young larva to seven in the adult, directly connected with the anal siphon by the tracheal sys-

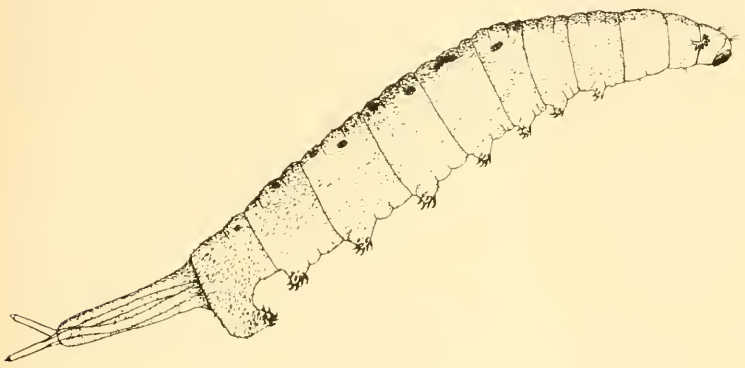

FIG. 103. Larva of *Ephydra millbræ*.

tem; siphon tapering, semi-transparent. When feeding, the larva draws the food in by a process of invagination in which the mouth parts are folded back into the head. The larva resembles in some respects that of *E. californica* Pack., but differs in the number of hooks on the abdominal tubercles and

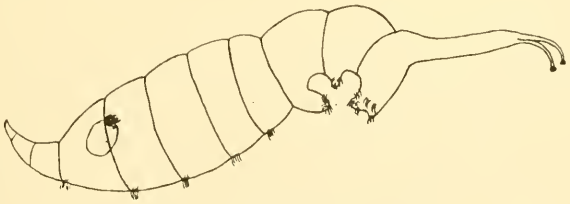

FIG. 104. Pupa of *Ephydra millbræ*.

in the form and size of the anal siphon and length of its accessory branches.

The puparium differs from that of *E. halophila* most noticeably in size, and from *E. gracilis* in the length of the anal siphon, which is much longer in the latter species; it is also much larger than *E. gracilis*. (Fig. 103.)

Pupa.—Puparium brownish black; length, about 12 mm. Seventh pair of legs small. Attached by last abdominal seg-

ment, anterior and extends into water, anal siphon protrudes. Pupa (young) white, naked; mouth parts pressed to the breast, indistinguishable; legs folded along the abdomen, head high between the eyes; wings reach to tarsi of second pair of legs. (Fig. 104.)

Note.—These flies have become very abundant along the southwest shore of San Francisco Bay between the small towns of San Mateo and San Bruno, the center of the colony seeming to be about Millbrae, where the floating puparia and adults

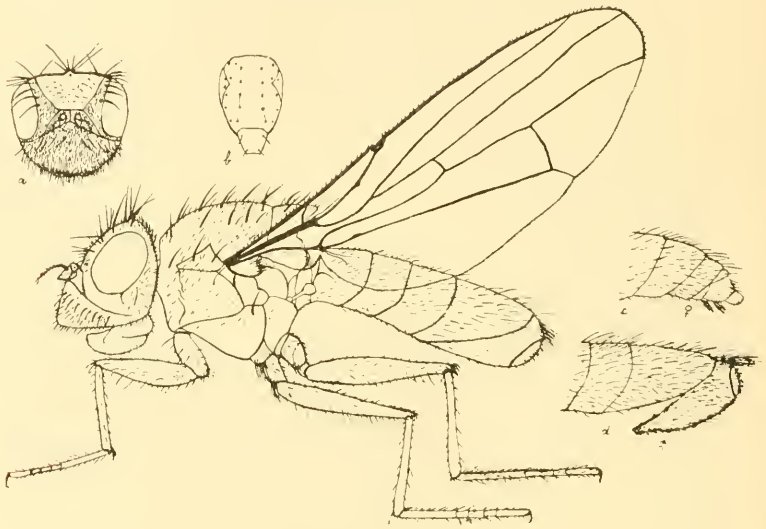

FIG. 105. *Ephydra millbrae*.

a. Head from above. *b*. Thorax from above, showing position of spines. *c*. End of abdomen of female. *d*. End of abdomen of male.

often cover the entire surface of the small salt-water ponds. Like mosquitoes, they seem unable to breed in water affected by the tide, but prefer the smaller pools that are practically without motion. The salinity of these marshes, owing to gradual evaporation during the summer and autumn months, often becomes much greater than that of the bay itself. I have found the flies living in ponds where the salinity was as high as 4.2 per cent, being almost one per cent higher than that of the average sea water. The migratory propensities do not seem to be very great and the immense colonies move about from pond to pond only as compelled by the absolute drying up of their habitat. The length of the life cycle is about the

same as that of the salt-marsh mosquitoes, which are often found in the same ponds. The adult flies abstract their nourishment from the surface of the water in which their larvæ live. They are especially fond of decaying animal matter, and will collect in swarms on water containing dead crabs or other animal bodies. The puparia are fastened in clusters to floating bits of vegetation and some even to the anal siphons of others. The adults crawl freely about over these floating puparia and lay their eggs upon them. These clusters of flies and puparia are shown in Plate I.

The puparia are very susceptible to the attacks of Chalcid parasites, and furnish an excellent breeding ground for them. From an aquarium in which I have bred out about seventy Ephydrids, seven of these Chalcid flies have emerged from the pupæ.

Ephydra cinerea, n. sp., ♂ and ♀.—Related to *E. hians* Say, but differs in the vittæ of the thorax, the green of the front and the very light color of the lower part of the legs. Entire insect densely cinereous pruinose, giving it a gray appearance seldom seen in members of this genus. Front brassy green, only slightly shining and densely pruinose; ocelli light orange yellow, ocellar triangle with dense fulvous pruinosity; third antennal joint also fulvous, almost umber; eyes spotted with black and deep orange yellow in varying proportions. Thorax above with three broad vittæ, varying from olivaceous at the margins to brassy green in the center; these stripes sometimes merge into an olivaceous patch with silky luster on the back of the mesothorax, usually obsolete on the scutellum. Abdomen usually concolorous, sometimes becoming yellowish toward the tip, with purplish bronze reflection, which is invisible except when the dense grayish pruinosity is rubbed off. Joints of trochanters, knees, tibiæ, and tarsi, except last joint, pale honey yellow densely clothed with grayish white pubescence; last joint of tarsi concolorous with body or slightly darker. A pair of strong macrochætæ, as strong as the four outwardly directed above each eye, just outside the ocellar triangle at the center of its sides; a very small, erect bristle just above the lowest ocellus; another, slightly larger, directly above this at the center of the triangle; a slightly longer pair barely inside the upper ocelli, and two more pairs directly

beyond these back of the vertex. Front very sparsely clothed with short erect hairs. Second antennal joint beset with short bristles; third joint without lateral pile; arista densely pubescent at the base with longer hairs, mostly above, toward the tip and last one fourth bare. Epistoma considerably protruding, strongly arched above, a row of five to six strong lateral bristles bordering it above on each side, usually with a smaller bristle between each two of the larger ones; another row of strong bristles about the oral margin. Thoracic pattern of macrochætæ normal above; pleuræ with a row of five to six strong bristles at the base of the wings, anterior portion usually beset with short hairs, a strong macrochæta directly above the intermediate coxæ. All of the macrochætæ and hairs black. Claws unusually long and straight. Wings grayish hyaline; veins light yellow at the base, darkening toward the apices; costa beset with short, stout hairs; unusually short, stout spines occurring at regular intervals to between the third and fourth longitudinals. Halteres pale yellow, almost stramineous. Length, 4.5 to 5 mm. Southern California.

EPHYDRIDAE OF THE UNIVERSITY COLLECTION.

Besides the species described above as new, I find the following in the collection of the University of California, not heretofore known to occur in this region:

Notiphila virgata Coquillett. The general color is much lighter than the type, and the vittæ of the thorax are brown rather than black. The pattern of these vittæ and the correspondence of the markings to the type leave no doubt as to its identity. Bakersfield, California.

Notiphila scalaris Löw. Though averaging about one fourth mm. larger than the type described by Professor Löw from the Middle States, the specimens here correspond very closely in color and markings. Southern California.

Hydrellia scapularis Löw. This is very similar to the type in many cases, specimens varying somewhat. Some have a whitish dot above the antennæ, and in others the markings of the legs vary slightly. A few specimens, which I regard

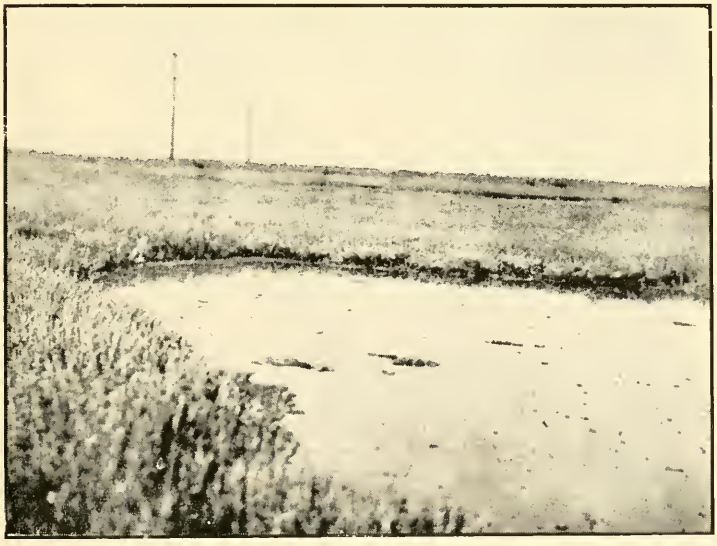

PLATE I. Breeding places of *Ephydra millbrae*.

as a variety of *H. scapularis*, have the face decidedly whitish instead of dark ochraceous as in the type; they are, however, identical in other respects. San Francisco and Rivera, California.

Parydra appendiculata Löw. Apparently identical with the type. Berkeley.

Scatophila hamifera Becker. Although representatives of this genus have not before been found in this country, there seems to be no doubt but that the specimens before me belong here. The macrochætal pattern of the thorax, the larger opening of the mouth, the sparse hairing of the face, and the fact that the costal vein ends at the third longitudinal point unmistakably toward *Scatophila*. The coloration of the various parts, the peculiar color pattern of the thorax above, as illustrated by Professor Becker (*Berl. Ent. Zeit.*, Vol. XLI, Taf. V, Fig. 11) and the number and position of the wing spots, mark our specimens as identical with the Norwegian *Scatophila hamifera*. Alameda, California.

Caenia bisetosa Coquillett. Redlands, California.

LITERATURE.

The following bibliography of the family Ephydridæ is primarily concerned with systematic works, but includes also all available references to insects in recognized genera. The method of reference carried out in the catalogue of species which follows consists of placing the date first, then the initial of the author, and finally the page reference. There are several cases in which similar initials occur at the same date, but in every such case the page reference will enable one to determine which author is referred to.

1776. **Degeer, Carl.** Mémoires pour servir a l'Histoire des Insects. VI. Stockholm.

1782. **Degeer, Carl.** German translation of the above, with notes by J. A. E. Gotze. VI.

1792. **Fabricius, Johann C.** Entomologia systematica emenda et aucta, secundum classes, ordines, genera, species, adjectis synonymis, locis, observationibus, descriptionibus. Hafniæ.

1798. **Fabricius, Johann C.** Supplementum Entomologiæ Systematicæ. Hafniæ.

1805. **Latreille, P. A.** Histoire Naturelle, générale et particulière des Crustaces et des Insects. Ouvrage faisant suite aux œuvres de Leclerc de Buffon et partie du cours complet l'Histoire Naturelle redigé p. C. S. Sounini. Paris. XIV.

Fabricius, Johann C. Systema Antliatorum. Brunsvigæ.

1809. **Latreille, P. A.** Genera Crustaceorum et Insectorum secundum ordinem naturalem in familias disposita, inconibus exemplisque plurimus explicata. IV.

1813. **Fallen, Carl F.** Beskrifning öfver några i Sverige fume vattenflugor. (Hydromizides.) Handlingar Konliga Svenska Vetenskaps Akademien. XXXIV, 240-257.

1820. **Fallen, Carl F.** Oscinides Sueciæ. Dissertat. Lund, Berling.

1823. **Fallen, Carl F.** Hydromyzides Sueciæ. Dissertat. Lund, Berling.

1830. **Meigen, Johann W.** Systematische Beschreibung der bekannten europaischen zweiflugligen Insecten. VI.

Robineau-Desvoidy, Andre J. B. Essai sur les Myodaires. Mémoires de le Savants étrang. Académien. Paris. II.

Say, Thomas. Descriptions of North American Dipterous Insects. Proceedings, Academy of Natural Sciences, Philadelphia, VI, 149-178.

Wiedemann, Christian R. W. Aussereuropaische zweiflugliche Insecten, als Fortsetzung des Meigenschen Werkes. II.

1832. **Curtis, John.** British Entomology, being illustrations and descriptions of the genera of insects found in Great Britain and Ireland. IX. London.

1833. **Haliday, Alexis H.** Catalogue of Diptera occurring about Holywood in Downshire. Entomological Magazine, I, 147-180.

1834. **Bouche, Peter F.** Naturgeschichte der insecten ebsonders in Hinsicht ihrer ersten Zustande als Larven und Puppen. I. Berlin.

1835. **Brulle, Auguste.** Coup d'œil sur l'Entomologie de la Morée. Annales Science Naturelle, III.

Macquart, Jean. Histoire Naturelle des Insectes Dipteres. (Suite à Buffon éd. Poret.) II. Paris.

1838. **Haliday, Alexis H.** Descriptions of New British Insects indicated in Mr. Curtis's Guide. Annals of Natural History, series 1, II.

Macquart, Jean. Diptères Exotique nouveaux ou peu connu. I.

Meigen, Johann W. Systematische Beschreibung der bekannten europaischen zweiflugligen Insecten. VII.

Zetterstedt, Johann W. Insecta Lapponica descripta. (Diptera.) Lipsæ Revue Zoölogie, 1838, I.

1839. **Haliday, Alexis H.** Remarks on the Generic Distribution of the British Hydromyzidæ. Annals of Natural History, series 1, III, 217-224.

1843. **von Heyden, Carl H. G.** Ueber Insecten die an den Salien leben. Stetteiner Entomologische Zeitung, IV, 227-229.

1844. **Stenhammar, C.** Forsok til Gruppering och Revision af de Svenske Ephydrinæ. Handlingar Kongliga Svenska Vetenskaps Akademien, 75-273.

von Heyden, Carl H. G. Ueber Insecten die an den Salinen leben. Stetteiner Entomologische Zeitung, V, 200-205.

1845. **Staeger, C.** Groenland's Antliater. In Kroyer's Naturhist. Tidskrift, new ser., I, 369.

1846. **Zetterstedt, Johann W.** Diptera Scandinaviæ deposita et descripta. Lund. V, 1739-2162.

1847. **Loew, Hermann.** Dipterologisches. Stetteiner Entomologische Zeitung, VIII, 368-376.

Perris, Edouardo. Lettre sur une Excursion dans le grande Landes. Mémoires Académie de Science Lyon, II, 433-506.

Rondani, Camillo. Nova Species generis Ochthera. Annals de la Société Entomologique de France, ser. 2, V, 29-31.

1848. **Loew, Hermann.** Ueber die Arten der Gattung Gymnopa. Stetteiner Entomologische Zeitung, IX, 13-15.

1849. **Walker, Francis.** Catalog of the Specimens of Dipterous Insects in the Collection of the British Museum. London. IV, 1098 *et seq.*

1852. **Boheman, Carl H.** Entomologiska Antekningar unter en resai Södra Sverige Vetensk. Acad. Handl. 53-210.

1853. **Haliday, Alexis H.** Insecta Britannica, II.

Walker, Francis. Insecta Britannica, Diptera. London. II, 247, tabs. 11-20.

1855. **Haliday, Alexis H.** Descriptions of Insects figured and references to plates illustrating the Notes on Kerry Insects. Natural History Review, II. Proc. 59-64.

Zetterstedt, Johann W. Diptera Scandinaviæ deposita et descripta. Lund. XII.

1856. **Haliday, Alexis H.** Insecta Britannica, Diptera. London. III.

Loew, Hermann. Neue Beitrage zur kentniss der Dipteren. IV, 55-57.

Rondani, Camillo. Dipterologiæ Italicæ. Prodromus. Parma.

Walker, Francis. Insecta Saundersiana; or, Characters of Undescribed Insects in the Collection of W. W. Saunders. London. V, 406.

Walker, Francis. Insecta Britannica Diptera. London. III, 352.

1857. **Walker, Francis.** Characters of Undescribed Diptera in the Collection of W. W. Saunders. Transactions of the Entomological Society of London, series 2, IV.

1860. **Loew, Hermann.** Beitrage zur kentniss der Dipteren. Berlin. VII.

Walker, Francis. Catalog of the Dipterous Insects collected in Makassar (Celebes) by Mr. A. R. Wallace, with Descriptions of New Species. Journal of the Proceedings of the Linnæan Society of London. Supplement to vol. IV, 163-169.

1861. **Loew, Hermann.** Diptera Americæ septentrionalis indigena. (Centuria prima.) Berliner Entomologische Zeitschrift, V.

von Frauenfeld, George R. Beitrage zur kentniss der Insecten-Metamorphose. (Diptera, etc.) Verhandlungen Zoölogische-Botanische Gesellschaft in Wien, XII, 163-174.

1862. **Egger, Johann.** Beschreibung neuer Zweiflugler. Verhandlungen in Wien der Zoölogische-Botanische Verein, X.

Loew, Hermann. Diptera Americæ septentrionalis indigena. (Centuria secunda.) Berliner Entomologische Zeitschrift, VI, 229.

Loew, Hermann. Monographs of the Diptera of North America. Edited by R. Osten Sacken. Washington, Smithsonian Institute. I, 127-172. (Smithsonian Miscellaneous Collections, vol. VI.)

1862. **Loew, Hermann.** Bidrag till kannedom om Africas Diptera. Ofvers Kongliga Vetenskaps Akademien Forhandling, XVII.

Schiner, J. R. Vorlaufiger Commentar zum dipterologischen Theile der Faunica Austriaca mit einer nahern Begrundung der in derselben aufgenommenen Dipterengattung. Weiner Entomologische Monatschrift, VI, 143-152.

1863. **Loew, Hermann.** Diptera Americæ septentrionalis indigena. (Centuria quarta.) Berliner Entomologische Zeitschrift, VII.

1864. **Bergenstamm, Julius von.** Ueber die Metamorphose von Discomyza incurva. Verhandlungen der Zoölogische-Botanische Gesellschaft in Wien, XIV, 713-716.

Dallas, W. S. Zoölogical Record, I.

Loew, Hermann. Ueber die zu Durenburg beobachteten halophilen Dipteren. Zeitschrift für die gesammten Naturwissenschaft, XXII, 346.

Loew, Hermann. Diptera Americæ septentrionalis indigena. (Centuria quinqua.) Berliner Entomologische Zeitschrift, VIII.

Loew, Hermann. *Ibid.* (Centuria 1-5), pp. 1-266.

Loew, Hermann. Diptera common to Europe and America. Silliman's American Journal of Science and Arts, XXXVII, 317.

Schiner, J. R. Fauna Austriaca. Die Fliegen, nach der analytischen Methode bearbeiten, II. Vienna.

1865. **Dallas, W. S.** Zoölogical Record, II, 663-664.

Loew, Hermann. Diptera Americæ septentrionalis indigena. (Centuria sexta.) Berliner Entomologische Zeitschrift, IX.

Walker, Francis. Descriptions of the Dipterous Insects of New Guinea. Proceedings of the Linnæan Society of London, VIII. (Jan. 13 and Dec. 5, 1865.)

1866. **Dallas, W. S.** Zoölogical Record, III, 512.

Frauenfeld, G. F. Zoölogische Miscellen, VII, 2. Der Metamorphoses von Hydrellia albilabris. Verhandlungen Zoölogische-Botanische Gesellschaft in Wien, XVI, 973-974.

Loew, Hermann. Diptera Americæ septentrionalis indigena. (Centuria septima.) Berliner Entomologische Zeitschrift, X, 50.

1868. **Dallas, W. S.** Zoölogical Record, V.

Packard, A. S. On Insects Inhabiting Salt Water. American Naturalist, II, 278-329. (Also, Proceedings and Comm. of the Essex Institute, VI, 41-54. March, 1869.)

Rondani, Camillo. Diptera aliqua in America meridionali lecta a Prof. S. Strobel annis 1866 et 1867. Annuario della Society dei Naturalisti in Modena, III, 32.

Shiner, J. R. Reise der osterreichischen Fregatte Novara um die Erde. Zoölogischer Theil. Diptera. 242.

Thompson, C. G. Kongliga Svenska Fregaten Eugenies Resa. (Dipteren.) Haft 12, 590-595.

1869. **Dallas, W. S.** Zoölogical Record, VI.

Loew, Hermann. Diptera Americæ septentrionalis indigena. (Centuria octava.) Berliner Entomologische Zeitschrift, XIII.

Loew, Hermann. Ueber Dipteren der Augsburger Umgegend. Berichtung naturh. Verein in Augsburg, XX, 39-59.

1870. **Verrall, G. H.** Zoölogical Record, VII.

1871. **Packard, A. S.** American Journal of Science and Arts, Feb., 103-105.

Rye, E. C. Zoölogical Record, VIII.

1872. **Holmgren, A. E.** Insecten fra Nordgronland, samlade af Prof. A. E. Nordenskiold ar 1870. Kongliga Vetenskaps Forhandlungar, no. 6, 97-105.

Loew, Hermann. Diptera Americæ septentrionalis indigena. (Centuria decima.) Berliner Entomologische Zeitschrift, XVI.

Loew, Hermann. *Ibid.* (Centuria 6-10), pp. 1-300.

Rye, E. C. Zoölogical Record, IX.

1873. **Loew, Hermann.** Diptera Nova in Pannonia inferiori et in confinibus Daciæ regionibus, a Ferd. Kowarzio capita. Berliner Entomologische Zeitschrift, XVII.

Loew, Hermann. Beschreibung europaischen Dipteren, II. (Part 10 of Meigen's Systematische Beschreibung der bekannten europaischen zweiflugelen Insecten.)

Rye, E. C. Zoölogical Record, X.

1874. **Loew, Hermann.** Ueber die Gattung Canace. Berliner Entomologische Zeitschrift, XVIII, 76-81.

Rye, E. C. Zoölogical Record, XI.

1875. **Eaton, A. E.** Breves Dipterarum unisque Lepidopterarum Insulæ Kerguelensi, indigenarum diagnose. Entomologists' Monthly Magazine, XII.

1878. **Kirby, W. F.** Zoölogical Record, XV.

Loew, Hermann. Neue Nordamerikanische Ephydrinen. Zeitschrift für die gesammten Naturwissenschaften Neue Folge. Berlin. LI, 192-203.

Osten Sacken, C. R. Catalog of the Described Diptera of North America. Smithsonian Miscellaneous Collections, XVI, 200-204.

1879. **Hagen, H.** Flies in a Petroleum Lake, Santa Cruz County, California. Proceedings of the Boston Society of Natural History, XX, 134.

Kirby, W. F. Zoölogical Record, XVI, 199.

Verrall, G. H. Zoölogy of the Kerguellen Islands—Diptera. Philosophical Transactions of the Royal Society of London, CLXVIII.

1881. **Karsch.** Archiv für Naturgeschichte, Neue Folge. Berlin. XLVII, 15, pl. 1, figs. 1-2.

Kirby, W. F. Zoölogical Record, XVIII.

Van der Wulp, F. M. Diptera in Midden-Sumatra Reizen en Onderzoekingen dem Sumatra Expeditie, etc. IV. 2de Aflevering. (Leidem, 1881.) Natuurlijke Histoire, 9de Afdeiling, 1-60, pls. 1-3.

1882. **Billups.** Discomyza incurva Noticed as New to Britain. Proceedings of the Entomological Society of London, 14.

1883. **Kirby, W. F.** Zoölogical Record, XX.

Packard, A. S., Jr. On Insects Used as Food. American Naturalist, XVII, 976.

Say, Thomas. Complete Writings of, On the Entomology of North America. Edited by John L. Le Conte, M. D. Vol. II. Philadelphia. (Originally published in the Journal of the Academy of Natural Sciences of Philadelphia, vol. III, 1823.)

1883. Van der Wulp, F. M. Amerikaansche Diptera. Entomologisk Tidskrift pa foranstaltande af Entomologiska Fore nuigen i Stockholm, XXVI, 1-60.

1884. Williston, S. W. Ephydra californica from Soda Lakes, Nevada. Transactions of the Connecticut Academy of Sciences, VI, 83-86.

1885. Roeder, Victor von. Dipteren von der Insel Porto Rico. Stettiner Entomologische Zeitung, 337-349.

1886. Gercke, G. Dipterologische Miscellanen. Weiner Entomologische Zeitung, V, 161-163.

Sharp, D. Zoölogical Record, XXIII.

Williston, S. W. Dipterological Notes and Descriptions. Transactions American Entomological Society, XIII, 287-307.

1887. Gercke, G. Einige Beobachtungen ueber die Eigenart der Canace ranula. Wiener Entomologische Zeitung, VI. 1-4.

Sharp, D. Zoölogical Record, XXIV.

1888. Bigot, J. M. F. Dipteres. Mission Scientifique du Cap Horn, VI, 1-45. (Also noticed by Mik, Wiener Entomologische Zeitung, VI, 164.)

Girschner, E. Dipterologische Studien, Beitrag zur Dipteren Fauna Thuringens. Entomologische Nachrichten, XIV.

Sharp, D. Zoölogical Record, XXV.

1889. Gercke, G. Dipterologische Miscellanen, series II. Wiener Entomologische Zeitung, VIII, 219-226.

Girschner, E. Eine Neue Art der Dipterengattung Psilopa. Entomologische Nachrichten, XV, 373.

Sharp, D. Zoölogical Record, XXVI.

Von Roder. Table of European Diptera. Entomologische Nachrichten, XV, 54-56.

1890. Hofmann, E. Notes on Teichomyza fusca in Stuttgart. Jahreshefte des Vereins für Vaterlandische Naturkunde in Wurttemburg (Stuttgart), XLVI, 239.

Scudder, S. H. Supposed Migration of Ilythea spilota. Psyche, V, 402.

Sharp, D. Zoölogical Record, XXVII.

1891. Bigot, J. M. F. Voyage de M. Ch. Alluaud aux îles Canaries, Dipteres. Bulletin de la Société Zoölogique de France (Paris), XIV, 279.

Schwarz, E. A. The Insect Fauna of the Great Salt Lake, Utah. Canadian Entomologist, XXIII, 235-241.

Sharp, D. Zoölogical Record, XXVIII.

Tournier, H. Materiaux pour contribuer à une faune suisse. L'Entomologiste Genevois. Journal mensuel d'Entomologie pure et appliquée (Geneva), I, 244.

Van der Wulp, F. M. Einige Uitlandische Diptera. Tijdschrift voor Entomologie, XXXIV, 215.

1892. Sharp, D. Zoölogical Record, XXIX, 301-302.

1893. Sharp, D. Zoölogical Record, XXX, 320-322.

Strobl, G. Neue Osterreichische Muscidæ acalypteræ. Wiener Entomologische Zeitung, XII, 253-256.

Williston, S. W. Insects of the Death Valley Expedition. North America Fauna, VII, 255-258.

1894. Strobl, P. G. Die Dipteren von Steiermark. Mittheilungen des naturwissenschaftlichen Vereins für Steiermark, XXIX and XXX.

1895. **Bezzi, M.** Contribuzioni alla fauna ditterologica Italiana. I. Ditteri della Calabria. Bulletino della Societa entomologica Italiana, XXVII, 70.

Bezzi, M. Eine neue Art der Dipterengattung Psilopa. Wiener Entomologische Zeitung, XIV, 137-138.

Giglio-Tos, E. Dittere del Messico. Porte Quarta. Memorie della Reale Accademia della Scienze di Torino, XLV, 1-74.

Johnson, Chas. W. Diptera of Florida. Proceedings of the Academy of Natural Sciences of Philadelphia, 303-340.

1896. **Becker, Th.** Dipterologische Studien IV, Ephydridæ. Berliner Entomologische Zeitschrift, XLI, 91-276.

Coquillett, D. W. A New Subfamily of Ephydridæ. Entomological News, VII, 220.

Sharp, D. Zoölogical Record, XXXIII, 290-292.

Slosson, Annie. List of Diptera from the White Mountains, N. H. Entomological News, VII, 264.

Wheeler, W. M. The Genus Ochthera. Entomological News, Philadelphia, VII, 121-123.

Williston, S. W. On the Diptera of St. Vincent (West Indies). Transactions of the Entomological Society of London, 389-404, pls. VIII-XIV.

Williston, S. W. Manual of the Families and Genera of North American Diptera, 110.

1897. **Kuntze, A.** Eine Neue Cænia. Deutsche Entomologische Zeitschrift heraus gegeben von der Deutschen entomologischen Gesellschaft. Berlin. 159.

Sharp, D. Zoölogical Record, XXXIV, 265-266.

Williston, S. W. Diptera Brasiliana, Part IV. The Kansas University Quarterly, VI, 1-12 (Jan., 1897).

1898. **Townsend, C. H. T.** Entomological News, IX, 168.

1899. **Coquillett, D. W.** Description of a New Psilopa. Canadian Entomologist, XXXI, 8.

Coquillett and Howard. Larva of Psilopa petrolei in Crude Petroleum. Entomologist, 235.

Gunther, R. T. Contributions to the Natural History of Lake Urmi, N. W. Persia, and its Neighborhood. Journal of the Linnæan Society, Zoology. London. XXVI, 415.

Howard, L. O. Scientific American (Feb. 4th), LXXX, 75.

Johnson, Chas. W. Catalog of the Diptera of New Jersey. Supplement to the 27th Annual Report of New Jersey State Board of Agriculture, 615-699.

Sharp, D. Zoölogical Record, XXXVI, 239-240.

1900. **Coquillett, D. W.** Report on a Collection of Dipterous Insects from Porto Rico. Proceedings of the United States National Museum, No. 1198, XXII, 259-261.

Coquillett, D. W. New Genera and Species of Ephydridæ. Canadian Entomologist, XXXII, 33-36.

Coquillett, D. W. Papers from the Harriman Alaska Expedition; Entomological Results (3). Proceedings of the Washington Academy of Sciences, II, 462.

Czereny, L. Neue œsterreichische Dipteren. Wiener Entomologische Zeitung, XIX, 205.

Howard, L. O. A Contribution to the Study of the Fauna of Human Excrement. Proceedings of the Washington Academy of Sciences, II, 541-604.

1900. **Lundbeck, Will.** Diptera Groenlandica, II. Nidenskaf elige Meddelelser Naturhistoriske Forening i Kjöbenhavn, 302-303.
Sharp, D. Zoölogical Record, XXXVII, 308-310.
Strobl, G. Spanische Dipteren, Part 8. Wiener Entomologische Zeitung, XIX, 1-4.
1901. **Coquillett, D. W.** Papers from the Hopkins-Stanford Galapagos Expedition; Entomological Results (2), Diptera. Proceedings of the Washington Academy of Sciences, III, 377-378.
Grimshaw, P. H. Diptera Fauna Hawaiiensis, III, 49.
Hutton, F. W. Synopsis of the Diptera Brachycera of New Zealand. Transactions and Proceedings of the New Zealand Institute, XXXIII.
Kertesz, C. Zwei Neue Ephygrobia-Arten von Singapore. Termeszetrajzi Fuzetek kiadja a Magyar nemzeti Museum (Budapest), XXIV, 81.
Sharp, D. Zoölogical Record. XXXVIII, 272-274.
1902. **Cockerell, T. D. A.** Some Insects of the Hudsonian Zone in New Mexico. Psyche, 346-347.
Coquillett, D. W. New Acalyptrate Diptera from North America. Journal of the New York Entomological Society, X, 182-184.
Slosson, Annie T. List of Diptera from the White Mountains, N. H. Entomological News, XIII, 8 and 320.
1903. **Coquillett, D. W.** A New Ephydrid from Australia. Entomological News, Philadelphia, XIV, 324.
Speiser, P. Eine Neue Dipterengattung mit rudimentaren Flugeln. Berliner Entomologische Zeitschrift, XLVIII, 65-67.
1905. **Aldrich, J. M.** A Catalog of North American Diptera. Smithsonian Miscellaneous Collections, XLVI, 623-631.

CATALOGUE AND SYNOPSES.

In giving a synopsis of this family whose members have such a wide geographical distribution, it is often a considerable task to bring the genera and species of the various authors into their proper relation to each other. The pattern of the thoracic macrochætæ has been most constantly and consistently used by the German systematists as a distinguishing character and has reached its perfection in the slightly conventionalized drawings used by Professor Becker in his monograph of the family in the *Berliner Entomologische Zeitschrift* for 1896, in which many of the genera are very briefly and concisely separated by this method. The fact that it has been largely overlooked by many English and American writers makes it quite difficult to define the generic limits of this family which is so well represented in both Europe and America, and also renders uncertain to those not familiar with the specimens the exact relation of a new genus to those already established, not

to mention the difficulty of effecting a compromise between the German and American synopses.

A genus not included here was described by Marquart (38M411) under the name *Blepharitarsis* with a type species *ornatus*, which was figured in *Dipteres* (Planches Vol.), taf. 34, fig. 5. There was a decided discrepancy, however, between the description and the figure, and the genus was left open to question in the later works of Löw, von Roder, and Becker, and will probably never be settled without reference to the original type which was found in Africa and was in the cabinet of M. Viard when seen by Macquart. If there is a distinctive mark of this genus at present available it is probably the long bristles of the hind tarsi.

Another genus, *Pegophila*, was described by Rondani (56R129) with a type species *meridionalis*, but it differs from *Notiphila* only in the possession of a somewhat shorter second longitudinal vein, and Professor Becker does not regard this as of generic value.

A subfamily, *Lipochactinae*, was established by Coquillett (96C220) with a single genus and species, *Lipochacta slossonae*, to accommodate some specimens taken in Florida. The following year this insect was relegated to the family *Agromyzidae*, subfamily *Ochthiphilinae*, by Professor Williston (97W7). Mr. Townsend, in describing his species *texensis*, states that it belongs to the genus *Lipochacta*, but differs from *slossonae* in that "the head is even broader than the thorax, clypeus projects fully the length of the face, front almost as wide but usually narrower than the oral opening, scutellum one third to one half as long as thorax, claws slender, a little elongate but not large or stout. The third and fourth veins converge toward their tip, but not strongly so." Every one of these characters, except the last, are given by Coquillett as generic and not specific, and every one differs from Mr. Townsend's species. Suppose this insect belongs to the genus *Lipochacta*, even though the description makes this impossible, then the only specific difference we have is the following:

"The third and fourth veins strongly, converging toward their tips.....*slossonae* Coq.

"The third and fourth veins converge toward their tips, but not strongly so.....*texensis* Towns."

In a family where so many discrepancies already exist I think we may be pardoned for not accepting one so marked as this.

The exact limits of this family and of several others that rank under the general terms of Calyptrate and Acalyptrate Muscidæ, are certainly becoming very indefinite as new genera and species are added, and it is to be hoped by students of Dipterology that some authority will revise these at an early date and that when certainly defined descriptions of both new and old forms be published, always under the name of the family to which they belong rather than the more general term, under which many of them may be overlooked in giving the synopsis of a single family.

KEY TO SUBFAMILIES.

1. Discoidal and hind basal cells united, anal cell lacking; auxiliary vein uniting at its extremity with the first longitudinal; third antennal joint more or less flat, not rounded..... 2
   Discoidal and hind basal cells distinct, anal cell present; auxiliary vein separate from the first longitudinal throughout; third antennal segment rounded.....**Canacenae**
2. Second joint of the antennæ unguiculated, or at least outer side of middle tibiæ with a few strong bristles....**Notiphilinae**
   Second antennal joint not unguiculated, outer side of middle tibiæ without bristles..... 3
3. Oral opening small, eyes with distinct hairing, seldom with indistinct hairing.....**Hydrellinae**
   Oral opening large, eyes without visible hairing....**Ephydrinae**

KEYS TO GENERA.

Subfamily NOTIPHILINÆ.

1. Second joint of antennæ with short, spinous bristle at the anterior upper end..... 2
   Second joint of antennæ without spinous bristles 17
2. Costal vein reaches to tip of third longitudinal..... 3
   Costal vein reaches to tip of fourth longitudinal..... 4
   Costal vein reaches beyond fourth longitudinal.....
   .....**Ptilomyia** Coquillett
3. Tip of male abdomen with elongated bristles..**Dichaeta** Meigen
   Tip of male abdomen without elongated bristles..**Notiphila** Fallen
4. Head with deep concavity at base of antennæ.....
   .....**Parephydra** Coquillett
   Head without deep concavity at base of antennæ..... 5
5. Abdomen broad, flat.....**Discomyza** Meigen
   Abdomen not broad..... 6

6. Third joint of antennæ lenticular.....**Discocerina** Macquart
Third joint of antennæ not noticeably lenticular..... 7
7. Upper side of intermediate tibiæ with a few long bristles..... 8
Upper side of intermediate tibiæ without long bristles..... 9
8. Wings with a costal spine, posterior transverse vein perpendicular, legs not prolonged, clypeus prominent..**Paralimna** Löw
Wings without costal spine, posterior transverse vein oblique, legs prolonged, clypeus hardly showing..**Corythophora** Löw
9. Antennal arista naked.....**Gymnopa** Fallen
Antennal arista not naked..... 10
10. Abdomen sharply edged, first and fifth segments greatly shortened in both sexes.....**Trimerina** Macquart
Abdomen not sharply edged, fifth segment not noticeably shortened, or shortened only in the males..... 11
11. Upper part of face flat, not carinate.....**Psilopa** Fallen
Upper part of face more or less carinate..... 12
12. First and fifth abdominal segments shortened in the males.... 13
All abdominal segments distinct in both sexes..... 14
13. Præscutellar bristle wanting, only one sternopleural bristle....
.....**Hecamede** Haliday
Two præscutellar bristles, two sternopleural bristles.....
.....**Allotrichoma** Becker
14. Clypeus prominent beneath the oral margin...**Athyroglossa** Löw
Clypeus hidden or projecting but little beyond the oral margin.. 15
15. Epistoma arched, with only one lateral bristle.....
.....**Ephygrobia** Schiner
Epistoma either slightly concave or kieled above, more than one lateral bristle..... 16
16. Thorax with one supraalar bristle.....**Clasiopa** Stenhammar
Thorax with three supraalar bristles.....**Paratissa** Coquillett
17. Wings normal..... 18
Wings small or rudimentary..... 24
18. Hind femora thickened and first joint of tarsi very long.....
.....**Amalopteryx** Eaton
Hind femora not greatly thickened and first joint of tarsi normal 19
19. Abdomen decidedly arched, pointed, first longitudinal vein long, arched at extremity.....**Cnestrum** Becker
Abdomen not decidedly arched or pointed, first longitudinal vein normal..... 20
20. Eyes haired, costal vein with two bristles at junction of first longitudinal.....**Atissa** Haliday
Eyes naked, costa without spines..... 21
21. Epistoma with a nose-like ridge above.....**Ilythea** Haliday
Epistoma arched above, or without nose-like protuberance..... 22
22. Epistoma decidedly arched.....**Philotelma** Becker
Epistoma not decidedly arched..... 23
23. One small fronto-orbital bristle on each side, tibiæ without bristles, oral opening small.....**Beckeriella** Williston
Two fronto-orbitals on each side, all of the tibiæ with a row of bristle-like hairs on the outer side, oral opening of moderate size.....**Gastrops** Williston
24. Wings short, scaly, halteres small.....**Apetaenus** Eaton
Wings rudimentary, clothed with hairs, halteres of usual size....
.....**Chamaebosca** Speiser

Subfamily HYDRELLINAE.

1. Eyes thickly pubescent 2
   Eyes sparsely pubescent or bare 4
2. Back of thorax without evident machrochætæ, antennal arista bare or feebly pubescent ..... **Glenanthe** Haliday
   Back of thorax with distinct dorso-central machrochætæ 3
3. Face convex ..... **Hydrellia** Rob.-Desv.
   Face slightly concave ..... **Nostima** Coquillett
4. Costal vein extending to third longitudinal ..... **Axysta** Haliday
   Costal vein extending to fourth longitudinal 5
5. Thorax with three pairs of dorso-central and two noto-pleural machrochætæ, sides of face without bristles ..... **Philygria** Stenhammar
   Thorax with only one pair of dorso-central machrochætæ and always one noto-pleural machrochæta, sides of face with bristles ..... **Hyadina** Haliday

Subfamily EPHYDRINAE.

1. Clypeus projecting 2
   Clypeus hidden 9
2. Oral opening small 3
   Oral opening large 7
3. Front femora much thickened, first posterior cell narrowed at the border of the wing ..... **Ochthera** Latreille
   Front femora moderately thickened, third and fourth veins parallel ..... **Ochtheroidea** Williston
   Front femora not thickened 4
4. Hind legs long, extremity of proboscis bent back to form a hook ..... **Ectropa** Schiner
   Hind legs not lengthened, extremity of proboscis not hook-shaped 5
5. Anterior part of mesonotum without bristles ..... **Pelina** Haliday
   Anterior part of mesonotum with bristles 6
6. Third joint of antennæ with an obtuse carina above ..... **Lytogaster** Becker
   Third joint of antennæ nearly round, large ..... **Domina** Hutton
7. Costal vein reaches to third longitudinal ..... **Brachydeutera** Löw
   Costal vein reaches to fourth longitudinal 8
8. Oral margin with several erect bristles laterally, auxiliary vein distinct from the first longitudinal throughout, thorax with five distinct dorso-central machrochætæ. ..... **Halmopota** Haliday
   Oral margin without bristles laterally, auxiliary vein coalescing with the first longitudinal except at its proximal end, thorax with only two to three dorso-central machrochætæ ..... **Parydra** Haliday
9. Claws almost straight, pulvilli indistinct ..... **Ephydra** Fallen
   Claws curved, pulvilli distinct 10
10. Costal vein reaches to third longitudinal 11
    Costal vein reaches to fourth longitudinal 12
11. Thorax with only a pair of humeral machrochætæ in front ..... **Scatophila** Becker
    Thorax with four rows of bristles extending to the anterior part ..... **Pelomyia** Williston

12. Antennal arista bare, first antennal joint forming an angle with the second and third.....**Teichomyza** Macquart
Antennal arista not bare, segments not forming an angle..... 13
13. Antennal arista pubescent.....**Scatella** Rob.-Desvoidy
Antennal arista pectinated..... 14
14. Femora not incrassated.....**Caenia** Rob.-Desvoidy
Femora slightly incrassated, metathorax elliptical, enormously developed, covering whole abdomen, legs short, stout, tibiae curved, wings concealed beneath metathorax..**Nomba** Walker

Subfamily CANACENAE.

1. Hind basal and anal cells distinct, auxiliary vein separate from first longitudinal.....**Canace** Haliday

NOTIPHILINAE.

PTILOMYIA Coquillett. Type *enigma*.
enigma Coq. 00C262, 008309, 05A624. Porto Rico.

DICHAETA Meigen. Type *caudata*.

North American Species.

1. Last abdominal segment comparatively short and blunt.....*brevicauda* Löw.
Last abdominal segment prolonged into a conical point or tubercle 2
2. Mesonotum with three indistinct brown vittæ.....*furcata* Coquillett.
Mesonotum with one brownish and four whitish gray vittæ .....*caudata* Fallen.

brevicauda Lw. 62L133, 78O8200, 95J338, 96B268, 05A623. Middle States, New Jersey, Florida.
caudata Fall. 62L133, 78O8200, 96B268, 0288, 05A623. Middle States.
furcata Coq. 02C182, 028263. Florida.

European Species.

2. **brevicauda** Lw. 60L5, 648236, 96B103. Silesia.
2. **caudata** Fall. 30M62, 44S194, 53W251, 56R129, 60L5, 648236, 96B103, *Notiphila* 23F8, 38Z717, 46Z1853. Whole of Europe.
tibialis Brulé. 32M318, 96B104. Europe.

NOTIPHILA Fallen.

North American Species.

1. Greater part of antennæ yellow..... 2
Third joint of antennæ yellowish at base...*decorata* Williston.
Third joint of antennæ reddish or reddish yellow at base.... 3
Greater part of antennæ reddish..... 6
Antennæ black throughout, or at least with third joint brownish..... 7

North American Species—*Continued.*

2. Pronotum with a median brownish vitta.....*varia* n. sp.
   Pronotum without such vitta.....*virgata* Coquillett.
3. Palpi blackish.....*pulchrifrons* Löw.
   Palpi yellowish..... 4
4. Upper side of thorax with broad brown lateral stripe.....
   .....*vittata* Löw.
   Upper side of thorax without such stripe..... 5
5. Abdomen with irregular brownish semifasciæ, each formed by two spots.....*carinata* Löw.
   Abdomen with two brown spots on each of the intermediate segments .....*unicolor* Löw.
   Abdomen dull, but without brown spots.....*avia* Löw.
6. Palpi blackish.....*solita* Walker.
   Palpi reddish yellow.....*erythrocera* Löw.
   Palpi light yellow.....*bellula* Williston.
7. Palpi yellowish.....*bella* Löw.
   Palpi blackish 8
8. Front with two black stripes separated by the ocellar triangle .....*decoris* Williston.
   Front without such stripes..... 9
9. Hind metatarsi with a strong black bristle on the under side .....*macrochacta* Löw.
   Hind metatarsi without such bristles..... 10
10. Wings slightly notched at the end of the first longitudinal....
    .....*producta* Walker.
    Wings without such notches..... 11
11. Chest with two gray stripes.....*transversa* Walker.
    Chest without such stripes..... 12
12. Upper side of thorax with five fine brown lines...*scalaris* Löw.
    Upper side of thorax with fewer or no vittæ.....
    .....*quadriseriosa* Thomson.

argentata. See **Brachydeutera.**

avia Lw. 78L193, 78OS200, 78K244, 96B268, 05A623. Hudson Bay Territory.

bella Lw. 62L133, 78OS200, 96B269, 05A623. Middle States.

bellula Will. 96W390, 96S291, 05A623. St. Vincent.

brevicornis. See **Hyadina nitida.**

carinata Lw. 62L137, 78OS200, 96B269, 05A623. Middle States, New Jersey.

decorata Will. 96W389, 96S291, 05A623. St. Vincent.

decoris Will. 93W258, 93S231, 05A623. Panamint Valley (California).

erythrocera Lw. 78L194, 78K244, 78OS201, 96B269, 05A623. Cuba.

guttata. See **Hyadina.**

guttata var. *brevicornis.* See **Hyadina nitida.**

macrochaeta Lw. 78L192, 78OS200, 78K244, 96B269, 05A623. Texas.

producta Walk. 49W1099, 78OS201, 96B266, 05A623. Hudson Bay.

pulchrifrons Lw. 72L102, 72L84, 72R389, 78OS200, 96B269, 97W52, 05A623. Texas.

North American Species—*Continued.*

quadrisetosa Thoms. 68T594, 70V442, 78OS200, 96B271, 05A623. California.
repleta. See **Scutella.**
scalaris Lw. 62L134, 78OS200, 96B268, 05A623. Middle States, New Jersey.
solita Walk. 56W406, 78OS201, 96B266, 05A623. United States.
transversa Walk. 56W407, 78OS201, 96B266, 05A623. United States.
unicolor Lw. 62L137, 64D559, 78OS200, 96B268, 05A623. Middle States.
varia n. sp.
virgata Coq. 00C259, 00S309, 05A623. Porto Rico.
vittata Lw. 62L136, 65L134, 78OS200, 96B268, 05A623. Middle States, New Jersey.

European Species.

albicans. See **Hecameda.**
albifrons. See **Hydrellia nigricans.**
albilabris. See **Hydrellia.**
annulipes Stenh. 44S203, 60L7, 64S238, 96B113. Scandinavia, Germany, Silesia.
aquatica Beck. 96B114, 96S291. Silesia, Poland.
australis Lw. 60L7, 64S239, 96B110. Germany, Greece, Asia Minor, Italy.
caesia. See **Hydrellia.**
caudata. See **Hydrellia.**
chalceata. See **Clasiopa.**
chamaeleon Beck. 96B114, 96S291. Pavia.
cinerea Fall. 13F250, 23F8, 30M64, 35M521, 38Z717, 44S200, 46Z1855, 60L7, 64S239, 96B112, *Keratocera palustris* 30RD788. Europe.
compta. See **Ephygrobia.**
concolor. See **Hydrellia.**
discolor. See **Hydrellia.**
dorsata Stenh. 44S198, 60L7, 64S239, 96B113. Scandinavia, Germany, Silesia.
erythrostoma. See **Hydrellia nigripes.**
flaviceps. See **Hydrellia discolor.**
flavicornis. See **Hydrellia.**
fulriceps. See **Hydrellia.**
fusca. See **Hydrellia.**
genicula. See **Hydrellia.**
glabrata. See **Ephygrobia.**
glaucella. See **Clasiopa.**
grisea. See **Hydrellia.**
griseola. See **Hydrellia.**
guttiventris Stenh. 44S206, 46Z1860, 60L7, 64S239, 96B111. Scandinavia, Germany.
incana. See **Hydrellia ranunculi.**
incurva. See **Discomyza.**
interstincta. See **Philygria.**
laticeps. See **Hydrellia.**

European Species—*Continued.*

maculata Stenh. 44S201, 46Z1862, 60L7, 64S239, 96B111. Scandinavia, Germany, Silesia.
madizans. See **Trimerina nigella.**
major Stenh. 44S196, 46Z1857, 96B111. Sweden.
mutata. See **Hydrellia.**
nigrella. See **Psilopa.**
nigricauda. See **Philygria.**
nigricornis Stenh. 44S202, 60L6, 64S237, 96B109. Scandinavia, Germany, Austria.
nigripes. See **Hydrellia.**
nymphaeae. See **Hydrellia.**
obscurella. See **Clasiopa.**
picta. See **Philydra.**
pilitarsis. See **Hydrellia.**
plumosa. See **Clasiopa.**
punctinervosus. See **Philygria.**
punctipennis Wied. 30W590, 96B266. Europe.
riparia Meig. 30M65, 35M522, 44S204, 60L7, 64S238, 96B112. Scandinavia, France, England, Germany, Silesia, Asia Minor.
stagnicola Stenh. 35M522, 44S197, 46Z1854, 60L6, 64S239, 96B109, *Keratocera* 30RD789. Scandinavia, Germany, Silesia.
tarsata. See **uliginosa.**
uliginosa Halid. 39H922, 60L6, 64S237, 96B109, *tarsata* 44S207. England, Scandinavia, Austria.
venusa Lw. 56L55, 60L7, 64S238, 96B112. Scandinavia, Germany, Austria, Silesia.
vittipennis. See **Philygria.**

Other Countries.

albiventris Wied. 30W589, 96B266. East Indies.
alboclavata Bigot. 88B41, 88S295, 96B272. Cape Horn.
bipunctata Lw. 62L12, 96B268. Swakop.
brasiliensis Walk. 56W408, 96B266. Brazil.
carbonaria Walk. 60W169, 65D663, 96B268. New Guinea.
chinensis Wied. 30W592, 96B266. China.
ciliata v. d. Wulp. 81W55, 81K253, 96B271. Sumatra.
costalis Walk. 56W408, 96B266. Brazil.
difficilis Wied. 30W591, 96B266. South America.
dorsopunctata Wied. 30W591, 91W215, 92S301, 96B266. East Indies.
exotica Wied. 30W590, 96B266. Montevideo.
fasciata Wied. 30W589, 96B266. East Indies.
flavilinea Walk. 60W170, 96B268. Celebes.
granifera Thoms. 68T594, 96B271. Insula Rossi.
ignobilis Lw. 62L12, 96B268. Cape of Good Hope. Swakop.
immaculata Wied. 30W592, 96B266. China.
indica Wied. 30W591, 96B266. East Indies.
insularis Grims. 01G49, 01S273. Oahu (Sandwich Islands).

Other Countries—*Continued.*

lineosa Walk. 60W170, 96B267. Celebes.
obscuricornis Lw. 62L12, 96B268. Swakop.
ortaloides Walk. 60W169, 64D559, 65D663, 96B268. Mysol.
peregrina Wied. 30W592, 96B266. China.
2. pulchrifrons Will. 97W5, 97S263. Brazil.
quadrifasciata Walk. 60W170, 96B267. Celebes.
radiatula Thoms. 68T595, 70V442, 96B271. China.
sinensis Schin. 68S241, 68D374, 83K251, 96B273. Hongkong.
smaragdi Walk. 49W1098, 96B266. Sierra Leone.
sternalis Thoms. 68T593, 70V442, 96B271. Manila.
striata Will. 97W5, 97S265. Brazil.
triangulifera Schin. 68S241, 68D374, 96B273. South America.
2. unicolor Walk. 60W169, 96B268. Mysol.
unilineata Walk. 60W169, 65D663, 96B268. New Guinea.

PAREPHYDRA Coquillett. Type *humilis.*
humilis Coq. 02C183, 05A626.

DISCOMYZA Meigen. Type *incurva.*

North American Species.

1. Antennæ yellowish red.....*balioptera* Löw.
Antennæ black.....*dubia* Williston.

balioptera Lw. 62L140, 78O8201, 96B268, 05A624. Cuba.
dubia Will. 96W392, 96S290, 05A624. St. Vincent.

European Species.

cimiciformis Halid. 38H124, 88G99, 88S295, 96B129. Germany, Ireland, East coast of Europe.
incurva Fall. 30M76, 35M529, 44S265, 60L8, 64B713, 64D559, 82B14, 82K252, 96B129, *Psilopa* 23F6, 46Z1941, *Notiphila* 64S241. Germany, North and Middle Europe, Britain.

Other Countries.

amabilis Kertez. 01K421, 01S272. Singapore.
obscurata Walk. 60W169, 96B267. Philippines.
pelagica Frnfld. 61F451, 96B273. Nikobara.
punctipennis v. d. Wulp. 81W56, 81K253, 96B271. Sumatra.
tenebrosa Walk. 60W169, 65D663, 96B267. New Guinea.

DISCOCERINA Macquart. Type *leucoprocta.*

North American Species.

1. Orbit of eyes white shining.....*orbitalis* Löw.
Orbit of eyes not shining, white..... 2
2. Abdomen black, at least at base..... 3
Abdomen not black..... 8

North American Species—*Continued.*

3. Last segment of abdomen white or silvery gray..... 4
Last segment of abdomen not white..... 5
4. Last segment and front angles of the two preceding segments of abdomen whitish pruinose.:.....*incisa* Coquillett.
White confined entirely to last segment of abdomen.....
.....*leucoprocta* Löw.
5. Face silvery gray with a medium black stripe..*nana* Williston.
Face uniform in color..... 6
6. Face vaulted, oral opening very large.....*facialis* Williston.
Oral opening of moderate size..... 7
7. Thorax black, shining through brownish dust.....
.....*obscura* Williston.
Thorax ash gray, opaque.....*parva* Löw.
8. Antennæ reddish yellow, third joint a little infuscated on the apical margin.....*lactcipennis* Löw.
Antennæ black, a whitish pollinose dot on the upper edge of the second joint.....*simplex* Löw.

calceata. See **Clasiopa.**
compta. See **Ephygrobia.**
facialis Will. 96W396, 96S290, 05A626. St. Vincent.
incisa Coq. 02C182, 02S263, 05A626. Porto Rico.
lacteipennis Lw. 62L145, 78OS201, 96B268, 05A626. Washington (D. C.), New Jersey.
leucoprocta Lw. 61L355, 62L148, 78OS201, 96B269, 96W395, 00C261, 05A626. Maryland.
nigritella. See **Ephygrobia.**
nana Will. 96W396, 96S290, 05A626. St. Vincent.
obscura Will. 96W397, 96S290, 05A626. St. Vincent.
obscurella. See **Clasiopa.**
orbitalis Lw. 61L354, 65L91, 62L147, 78OS201, 96B369, 05A626. Washington (D. C.).
parva Lw. 62L146, 78OS201, 96B268, 00C261, 00H592, 05A626. Washington (D. C.), Florida.
pulicaria. See **Clasiopa.**
simplex Lw. 61L354, 62L147, 78OS201, 96B369, 05A626. Maryland.

PARALIMNA Löw. Type *appendiculata.*

North American Species.

1. Face brownish gray.....*obscura* Williston.
Face grayish white..... 2
Face yellowish white..... 3
2. First joint of front tarsi at base and first joint of hind tarsi red.....*appendiculata* Löw.
First joint of front and hind tarsi concolorous or yellowish
.....*multipunctata* Williston.
3. Thorax black, antennæ black throughout.....*decipiens* Löw.
Thorax with grayish pruinosity, third antennal joint yellow
.....*nuda* Coquillett.

appendiculata Lw. 62L138, 78OS201, 95J338, 96B268, 05A624. Middle States, New Jersey.

North American Species—*Continued.*

decipiens Lw. 78L195, 78OS201, 78K244, 96B270, 00C259, 05A624. Texas, Georgia, Florida.
multipunctata Will. 96W390, 96S291, 05A624. St. Vincent.
nuda Coq. 02C182, 02S264, 05A624. Mexico.
obscura Will. 96W391, 96S291, 05A624. St. Vincent, Porto Rico.

European Species.

2. **appendiculata** Lw. 62L138, 96B115. Germany.

Other Countries.

albonotata Lw. 62L13, 96B268. Caffraria.
confluens Lw. 62L13, 96B268. Caffraria.
javana v. d. Wulp. 91W215, 92S302, 96B271. Java.
limbata Lw. 62L13, 96B268. Caffraria.
picta Kert. 01K423, 01S273. New Guinea.

CORYTHOPHORA Löw. Type *longipes.*
longipes Lw. 62L13, 96B116, 96S290. Caffraria.

GYMNOPA Fallen. Type *subsultans.*
aenea. See **subsultans.**
albipennis Lw. 48L14, 96B127. Germany, Messina.
nigra. See **subsultans.**
subsultans Fabr. 48L13, 56R128, 64S234, 96B127. *nigra* 30M137, *aenea* 23F10, 30M137, *Ulida* 46Z2679, *arcuata* 35M505, *Syrphus* 1798F304, *Mosillus arcuatus* 1809L389, *Glabrinus mororum* 56R132. Europe.

TRIMERINA Macquart. Type *Psilopa madizans* Meig.
nigella Meig. 60L8, 64S240, 94B117, *madizans* 35M529, *Notiphila* 30M72, *Psilopa* 23F7, *nigella* 44S263. Germany, North and Middle Europe.
tibialis Macq. 35M528, 96B117. Europe.

PSILOPA Fallen.

North American Species.

1. Entire legs, including the coxæ, yellow....*mellipes* Coquillett.
Legs not entirely yellow..... 2
2. Thorax black anteriorly, posterior part scoriaceous.....
.....*scoriacea* Löw.
Mesonotum of thorax deep brown.....*desmata* Williston.
Mesonotum and scutellum subopaque, slightly scabrous, thinly gray pruinose.....*similis* Coquillett.
Mesonotum and scutellum thinly yellowish dusted.....
.....*nigrimana* Williston.
Mesonotum and scutellum yellowish, usually polished.....
.....*flavida* Coquillett.
Mesonotum and scutellum gray or dusted with gray..... 3
Mesonotum and scutellum green or tinged with green..... 5
Mesonotum and scutellum black..... 7

North American Species—*Continued.*

3. Abdomen shining steel blue.....*coeruleiventris* Löw.
   Abdomen black..... 4
4. Antennæ reddish yellow.....*umbrosa* Löw.
   Antennæ black.....*nigra* Williston.
5. Hypopygium white.....*nobilis* Löw.
   Hypopygium not white..... 6
6. First joint of anterior tarsi white.....*pulchripes* Löw.
   First joint of anterior tarsi not white.....*varipes* Coquillett.
7. Thorax finely aciculate.....*aciculata* Löw.
   Thorax not finely aciculate..... 8
8. A minute blackish spot at the tip of the third vein.....
   .....*nigropuncta* Williston.
   No black spot at tip of third vein..... 9
9. Halteres white, petiole blackish.....*atra* Löw.
   Halteres white, petiole yellowish.....*petrolei* Coquillett.
   Petiole of halteres concolorous..... 10
10. Entire abdomen shining black.....*nitidula* Fallen.
    Abdomen with a greenish reflection.....*atrimana* Löw.
    Abdomen black, dull toward the tip.....*aenea-nigra* Löw.

aciculata Lw. 62L142, 78OS201, 96W394, 96B268, 97W4, 00C260, 05A624. Cuba.

aenea-nigra Lw. 78L196, 78K244, 78OS201, 05A624. Texas.

atra Lw. 62L143, 78OS201, 96B268, 05A624. Middle States.

atrimana Lw. 78L197, 78K244, 78OS201, 05A625. Texas, New Jersey.

coeruleiventris Lw. 62L144, 78OS201, 96B268, 05A625. Cuba.

desmata Will. 96W395, 96S291, 05A625. St. Vincent.

flavida Coq. 00C33, 00S310, 05A625. Massachusetts.

mellipes Coq. 00C260, 05A625. Porto Rico.

nigra Will. 96W393, 96S291, 05A625. St. Vincent.

nigrimana Will. 96W393, 96S296, 97W4, 00C260, 05A625. St. Vincent, Porto Rico.

nigropuncta Will. 96W393, 96S291, 05A625. St. Vincent.

nitidula Fall. 13F252, 05A625. *Notiphila* 49W1089. *Ephygrobia* 96B266. Martin Falls (Canada).

nobilis Lw. 62L229, 72L92, 78OS201, 05A625. District of Columbia.

petrolei Coq. 99C8, 99C&H235, 99H175, 99S240, 05A625. California.

pulchripes Lw. 78L197, 78K244, 78OS201, 05A625. Texas.

scoriacea Lw. 62L142, 78OS201, 96B268, 05A625. New York, New Jersey.

similis Coq. 00C33, 00S310, 05A625. Florida, Louisiana.

umbrosa Lw. 62L143, 78OS201, 96B268, 05A625. Cuba.

varipes Coq. 00C33, 00S310, 05A625. British Columbia.

European Species.

apicalis. See **Ephygrobia.**

compta. See **Ephygrobia.**

girschneri. See **Ephygrobia.**

European Species—*Continued.*

leucostoma. See **Ephygrobia.**
nigrotaeniata Bezzi (*Diascmocera* new subgenus). 95B137, 95S344. Italy.
madzans. See **Trimerina nigrella.**
marginella. See **Ephygrobia.**
maritima. See **Ephygrobia.**
nigrella. See **Trimerina.**
nitidula Fall. 13F252, 23F7, 44S261, 46Z1932. *Hydrellia Notiphila* 49W1098, 60L10, 89R56. *Ephygrobia* 64S242, 96B143. Silesia, South Russia, Sarepta. See also **Ephygrobia compta.**
obscuripes. See **Ephygrobia.**
polita. See **Ephygrobia.**
rodcvi. See. **Ephygrobia.**
tarsata. See **Ephygrobia.**

Other Countries.

metallica Schin. 68S242, 97W4. Brazil.

HECAMEDE Haliday. Type *albicans.*

abdominalis. See **Allotrichoma.**
albicans Meig. 39H224, 53W254, 56W344, 60L13, 96B121, *Notiphila* 30M65, 38Z4760, *Clasiopa globifera* 52B204. Coast of Europe.
aurella Strohl. 93S256, 93S321. Styria.
glaucella. See **Clasiopa.**
xanthoccra. See **Clasiopa.**

ALLOTRICHOMA Becker. Type *lateralis.*

North American Species.

abdominalis Will. 97W4, 00C260, 05A624, *Hecamede* 96W398. St. Vincent.

European Species.

bezzi Beck. 96B123, 96S290. Italy.
filiformis Beck. 96B123, 96S290. Sarepta, Italy.
lateralis Lw. 60L13, 96B122. Italy, Sicily.
trispinum Beck. 96B124, 96S290. Silesia, Malta.

Other Countries.

2. **abdominalis** Will. 00C260. Brazil.

ATHYROGLOSSA Loëw. Type *glabra.*

North American Species.

1. Tarsi white, except the last segments, which are brown..... .....*glaphyropus* Löw.
   Tarsi not white..... 2
2. Wings hyaline.....*glabrata* Meigen.
   Wings tinged with brown.....*nitida* Williston.

glabrata Meig. 56W254, 60L12, 64S254, 96B134, 05A625, *Notiphila* 30M69. Washington.
glaphyropus Lw. 78L198, 78OS202, 78K244, 96B270, 05A626. Texas.
nitida Will. 96W397, 96S290, 00C260, 05A626. St. Vincent, Porto Rico.

European Species.

glabra Meig. 30M69, 53W254, 60L12, 64S245, 96B134. Germany, Silesia.

nudiuscula Lw. 73L307, 73R426, 73L50, 96B134. Hungary, Kasan.

ordinata Beck. 96B135, 96S290. Orsova.

EPHYGROBIA Schiner. Type *nitidula*.

European Species.

apicalis Perris. 64S242, 96B138, *Hydrellia* 47P494, *Psilopa* 60L9, 89R56. Germany, France.

compta Meig. 30M68, 64S243, 96B143, *Discomyza* var. *B. nitidula* 44S261, *Psilopa* 46Z1932, *Hydrellia compta* 35M524, *Psilopa* 60L56, 89R56. Europe, Silesia.

girschneri v. Rod. 96B141, *Psilopa* 89R55, 89S287. Fundort, Saxony, Poland.

leucostoma Meig. 64S243, 96B142, *Notiphila* 30M68, *Hydrellia* 35M524, *Psilopa* 44S261, 46Z1936, 60L9, 89R56. Sweden, England, France, Germany, Hungary, Russia.

marginella Fall. 96B139, *Psilopa* 23F7, 46Z1939, 55Z4762, *Discomyza* 44S266. Europe.

maritima Perris. 96B139, *Hydrellia* 47P494, *Psilopa* 73L306, 89R56. France.

nana Lw. 96B142, *Psilopa* 60L9, 89R56. Constantinople, Sylt Island.

nigritella Stenh. 64S242, 96B144, *Discomyza* 44S262, *Psilopa* 46Z1935, 60L10, 89R56. Scandinavia, Germany, Austria, Silesia.

nitidula. See **Psilopa**.

obscuripes Lw. 96B144, *Psilopa* 60L10, 89R56, 94S124. Greece, Asia Minor, Hungary.

plumosa. See **Clasiopa**.

polita Macq. 64S243, 96B144, *Hydrellia* 37M524, *Psilopa* 60L10, 89R56, *tarsata* 46Z1934. North and Middle Europe, Silesia.

roderi Girsch. 96B140, *Psilopa* 89G373, 91T244, 91S275, *Diasemocera nigrotaeniata* 95B137. Fundort, France, Italy.

Other Countries.

metallica Schin. 68S242, 69D374, 96B273. South America.

nigricauda Bigot. 91B278, 91S275. Canary Islands.

pollinosa Kert. 01K81, 01S273. Singapore.

singaporensis Kert. 01K81, 01S273. Singapore.

CLASIOPA Stenhammar.

European Species.

aurifacies Strobl. 93S255, 93S320, 96B157. Styria, Silesia.

aurivillii Beck. 96B158, 96S290. Sweden.

bohemanni Beck. 96B159, 96S290. Sweden.

brevipectinata Beck. 96B149, 96S290. Norway.

European Species—*Continued.*

calceata Meig. 64S244, 96B157, *nigrina* 44S254, 46Z87, *Notiphila* 30M69, *Discocerina* 35M524, 60L11, var. *flavoantennata* 00S1, 00S308. North and Middle Europe, Silesia.

cinerella Stenh. 44S251, 96B158. Germany, Sweden.

costata Lw. 60L14, 96B160. Turkey, Asia Minor.

coxalis Strobl. 93S253, 93S320, 96B157. Styria.

dimidiatipennis Strobl. 93S255, 93S320, 96B150. Styria.

duplosetosa Beck. 96B162, 96S290. Malta, Orsova.

fulgida Beck. 96B156, 96S290. Orsova.

glabricula Fall. 44S256, 64S244, 96B152, *Notiphila* 13F251, 23F10, 46Z1893. Silesia.

glaucella Stenh. 44S253, 96B160, *Notiphila* 46Z1883, *Hecamede* 60L14, 64S245, 94S126. Hungary, Sweden, Styria, Silesia.

globifera. See **Hecamede albicans.**

nigerrimana Strobl. 93S254, 93S320, 96B151. Styria.

nivea Beck. 96B151, 96S290. Malta. Silesia.

niveipennis Beck. 96B162, 96S290. Silesia.

obscurella Fall. 44S254, 64S244, 96B148, *Notiphila* 13F251, 23F10, 30M73, *Discocerina* 60L11. North and Middle Europe.

olivacea Beck. 96B155, 96S290. Herkulesbad.

palliditarsis Beck. 96B155, 96S290. Silesia.

pallidula Stenh. 44S257, 96B150. Scandinavia.

plumosa Fall. 60L10, *Ephygrobia* 64S242, 94S125, 96B150, *Psilopa* 23F9, 55Z27, *longula* 44S259, *Notiphila* 30M73. North and Middle Europe. Silesia.

pulicaria Halid. 53W254, 96B155, *fuscella* 44S256, 46Z1893, *Discomyza* 39H224. Europe.

xanthocera Lw. 96B161, *Hecamede* 69L58, *aurella* 93S250. Germany, The Alps, Silesia.

Other Countries.

albitarsis v. d. Wulp. 81W56, 81K253, 96B271. Sumatra.

PARATISSA Coquillett. Type *pollinosa.*

pollinosa Will. 00C36, 05A626, *Drosophila pollinosa* 96W404. Florida, St. Vincent.

AMALOPTERYX Eaton. Type *maritima.*

maritima Eaton. 75E58, 96B272. Kerguelen Islands.

CNESTRUM Becker. Type *lepidopes.*

lepidopes Beck. 96B118, 96S290. Germany, Silesia.

ATISSA Haliday. Type *pygmaea.*

durrenbergensis Lw. 64L346, 64D512, 96B131. Thuringen.

limosina Beck. 96B132, 96S290. Norway, Christiania.

pygmaea Halid. 33H174, 53W258, 64S251, 89G223, 89S287, 96B131, *ripicola* 60L24. Germany, Ireland, Italy.

ripicola. See **pygmaea.**

ILYTHEA Haliday. Type *spilota*.

North American Species.

1. Legs brownish black with yellow rings at the knees.....
.....*spilota* Curtis.
Legs yellow, the tips of the tarsi brownish..*flavipes* Williston.

flavipes Will. 96W403, 97W4, 00C260, 05A625. St. Vincent, Porto Rico.
?oscitans Walk. 57W233, 78OS262, 96B268, 00C260, 05A625. United States.
See **Ephydra** and **Scatella**.
spilota Curt. 60L37, 78OS204, 05A625. North America.

European Species.

2. **spilota** Curt. 32C413, 53W264, 64S263, 96B133, *notata* 44S186. North and Middle Europe, Silesia.

PHILOTELMA Becker. Type *anomala*.
anomala Beck. 96B164, 96S291. Kohlfarter Moor (Silesia).

BECKERIELLA Williston. Type *bispinosa*.
bispinosa Thoms. 97W2, 97S265, *Ephydra bispinosa* 68T593, 70V442, 96B271. Rio de Janeiro.

GASTROPS Williston. Type *niger*.
1. Antennæ red, third joint at tip and on upper part black....
.....*niger* Williston.
Antennæ, except upper edge and sometimes broad apex of third joint yellow.....*nebulosus* Coquillett.

nebulosus Coq. 00C34, 05A624. North Carolina, Georgia.
niger Will. 97W3, 97S265,, 05A624. Grenada (W. I.), Rio Janeiro.

APETAENUS Eaton. Type *litoralis*.
litoralis Eaton. 75E58, 96B272. Kerguelen Islands.

CHAMAEBOSCA Speiser. Type *microptera*.
microptera Speis. 03S67. Chile.

Note.—Mr. Coquillett seems to have recognized that the species *oscitans* (Walker) belongs in this genus (00C260). In Smith's Catalog of New Jersey species it is placed in **Scatella**. The original Walker description, which places it in **Ephydra**, does not make the generic characters sufficiently certain. It appears that Coquillett or Johnson (Smith's Catalog) should give us a description of this species by which an agreement might be reached in regard to its generic relations. If an **Ilythea**, *oscitans* differs from both *spilota* and *flavipes* in that the antennal arista is bare, while in the former there are six to eight rays and in the latter eight.

HYDRELLINAE.

GLENANTHE Haliday. Type *ripicola*.

fuscinervis Beck. 96B165, 96S291. Norway.

ripicola Halid. 39H404, 53W258, 60L16, 64S246, 96B165. Europe.

HYDRELLIA Robineau-Desvoidy. Type *griseola*.

North American Species.

1. Entire legs yellow.....*gilvipes* Coquillett.
   Legs not entirely yellow..... 2
2. All of the coxæ yellow.....*pulchra* Williston.
   Only the anterior coxæ yellow.....*ischiaca* Löw.
   None of the coxæ yellow..... 3
3. Face shining white.....*formosa* Löw.
   Face snowy white.....*hypoleuca* Löw.
   Face pale yellow..... 4
   Face dark yellow, narrow, much widened below.....
   .....*scapularis* Löw.
   Face brownish-black opaque..... 5
4. Face rather broad, but little widened below.....*valida* Löw.
   Face narrow, much dilated below as in *scapularis*.....
   .....*conformis* Löw.
5. Abdomen brownish metallic green, somewhat glossy.....
   .....*obscuripes* Löw.
   Abdomen black but little shining, thinly grayish dusted.....
   .....*parva* Williston.

apicalis. See **Ephygrobia**.

compta. See **Ephygrobia**.

conformis Lw. 69L41, 72L73, 69D444, 78OS202, 96B270, 05A626. Newport (R. I.).

formosa Lw. 61L355, 62L154, 65L94, 78OS202, 96B270, 00H593, 05A626. Pennsylvania.

gilvipes Coq. 00C261, 00S309, 05A627. Porto Rico.

hypoleuca Lw. 62L151, 78OS202, 96B269, 05A627. Middle States.

ischiaca Lw. 62L150, 78OS202, 96B269, 05A627. Middle States.

maritima. See **Ephygrobia**.

nitidula. See **Psilopa**.

obscuripes Lw. 62L152, 78OS202, 96B269, 02S8, 05A627. Middle States, White Mountains (N. H.).

parva Will. 96W399, 96S291, 05A627. St. Vincent.

pulchra Will. 96W400, 96S291, 05A627. St. Vincent.

scapularis Lw. 62L153, 78OS202, 96B269, 00C461, 02S320, 05A627. New Jersey, Illinois west to California.

valida Lw. 62L153, 78OS202, 96B269, 05A627. Middle States.

European Species.

albiceps. See **mutata**.

albifrons. See **nigricans**.

albilabris Meig. 53H258, 56H345, 60L18, 64S248, 66F973, 66D512, 96B183, *argyria* 30RD793, *argyrostoma* 44S236, *Notiphila* 46Z1895, *albilabris* 30M71. North and Middle Europe, Silesia.

European Species—*Continued.*

argyrostoma. See **albilabris.**

arygrogenis Beck. 96B185. 96S290. Milan.

caesia Stenh. 44S214, 60L18, 64S249, 96B176, *Notiphila* 46Z1880. Sweden, Germany.

cardamines. See **flavilabris** and **laticeps.**

concolor Stenh. 44S216, 60L20, 64S247, 96B178, *cinerascens* 35M526, *Notiphila concolor* 46Z1877. Sweden, Germany, Austria.

discolor Stenh. 44S230, 60L22, 64S250, 96B179, *flaviceps* 39H345, *Notiphila* 30M72, *discolor* 46Z1900. England. Sweden, Germany, Hungary, Silesia.

erythrostoma. See **nigripes.**

flavicornis Fall. 96B177. *Notiphila* 23F10, 46Z1873. Germany, Sweden, Hungary, Silesia. See also **nigripes.**

flavilabris Stenh. 44S235, 94S126, 96B173, *cardamines* 39H402. Styria.

frontalis Lw. 60L19, 64S249, 96B183. Silesia.

fulviceps Stenh. 44S231, 60L21, 64S248, 96B173, *Notiphila* 46Z1901, *chrysostoma* 30M67. Germany, Sweden, Silesia.

fusca Stenh. 44S225, 60L24, 64S250, 96B178, *Notiphila* 46Z1896. Sweden, Germany.

genicula Stenh. 44S224, 60L18, 64S248, 96B174, *Notiphila* 46Z1878. Germany, Sweden.

grisea. Stenh. 44S227, 60L21, 64S249, 96B179, *Notiphila* 46Z1898. Sweden, Germany, Russia.

griseola Fall. 44S220, 60L22, 64S247, 96B180, *Notiphila* 13F254, 23F9, 30M66, 38Z717, 46Z1869. Europe, Silesia.

hispanica. See **nigricans.**

incana. See **ranunculi.**

lamina Beck. 96B184, 96S291. Leignitz.

lapponica Stenh. 44S237, 96B174. Pavia.

laticeps Stenh. 44S229, 60L20, 64S248, 96B172, *cardamines* 39H402, *Notiphila laticeps* 46Z1899. North and Middle Europe, Silesia.

maculiventris Beck. 96B175, 96S291. Silesia.

modesta Lw. 60L23, 64S250, 96B181. Europe.

mutata Zett. 60L19, 64S247, 94S126, 96B176, *plumosa* 44S218, *albiceps* 56W345, *Notiphila mutata* 46Z1876. Sweden, Germany, Silesia.

nigricans Stenh. 44S234, 64S250, 96B183, *nigrina* 60L24, var. *hispanica* 00S1, 00S309, *albifrons* 44S223, *Notiphila* 23F10. Sweden, Germany, Austria.

nigrina. See **nigricans.**

nigripes Zett. 60L22, 64S248, 96B181, *flavicornis* 44S232, 56W345, *erythrostoma* 53W257, *Notiphila* 30M69, *nigripes* 38Z717. North and Middle Europe, Silesia.

nymphaeae Stenh. 44S227, 60L23, 96B182, *Notiphila* 46Z1897. Sweden.

pilitarsis Stenh. 44S219, 60L20, 64S249, 96B173, *Notiphila* 46Z1881. Sweden, Germany.

plumosa. See **mutata.**

European Species—*Continued.*

ranunculi Halid. 39H402, 53W256, 60L23, 64S247, 96B182, *incana* 44S222, *Notiphila* 46Z1871, *griseola* 23F9. Europe, Silesia.

thoracica Halid. 39H402, 53W256, 60L18, 64S249, 96B183. England, Germany, Silesia.

transsylvana Beck. 96B184, 96S291. Transylvania.

Other Countries.

tritica Coq. 03C324. Australia.

NOSTIMA Coquillett. Type *slossonae*.

slossonae Coq. 00C35, 00S310, 05A627. Florida.

AXYSTA Haliday. Type *cesta*.

cesta Halid. 33H177, 53W262, 60L28, 64S255, 96B167, *Philygria punctulata* 44S241, *Trimerina coeruleiventris* 35M529. North and Middle Europe.

PHILYGRIA Stenhammar.

North American Species.

1. Posterior portion of abdomen differing in color, or at least in lustre from anterior portion 2
   Abdomen concolorous throughout 3
2. Prevailing color blackish cinereous, antennæ entirely black .....*debilis* Löw.
   Prevailing color brownish gray, third antennal joint reddish, yellow beneath .....*vittipennis* Zetterstedt.
3. Prevailing color brown 4
   Prevailing color black 5
4. Transverse veins margined with blackish brown .....*fuscicornis* Löw.
   Transverse veins broadly clouded with black .....*opposita* Löw.
5. Coxæ light yellow .....*nitida* Williston.
   Coxæ black .....*nitifrons* Williston.

debilis Lw. 61L357, 62L157, 65L96, 78OS202, 96B269, 02S8, 05A627. Pennsylvania, White Mountains (N. H.).

fuscicornis Lw. 62L155, 78OS202, 96B269, 02S8, 05A627. Middle States, White Mountains (N. H.).

nitida Will. 96W400, 96S291, 05A627. St. Vincent.

nitifrons Will. 96W401, 96S291, 05A627. St. Vincent.

opposita Lw. 61L356, 62L156, 65L95, 78OS202, 96B269. Pennsylvania.

vittipennis Zett. 78OS202, 96B270. Greenland.

European Species.

abdominalis. See **Lytogaster**.

femorata Stenh. 44S245, 64S253, 96B190, *Notiphila* 23F12. Scandinavia, Germany, Silesia.

flavipes Fall. 35M525, 44S244, 60L26, 64S252, 96B191, *Notiphila* 23F12, 46Z1916, *Ephydra* 30M123. Europe, Silesia.

interrupta Halid. 53W261, 60L26, 64S253, 96B189, *Hydrina* 34H176. Middle Europe, Silesia.

European Species—*Continued.*

interstincta Fall. 44S246, 64S253, 96B190, *Notiphila* 13F254, 23F12, 46Z1919. Europe.

nigricauda Stenh. 44S248, 96B192, *Notiphila* 46Z1923. Scandinavia, Germany, Silesia, Transylvanian Alps.

obtecta Beck. 96B122, 96S291. Silesia.

picta Fall. 44S243, 60L25, 64S253, 96B192, *Notiphila* 13F254, 23F11, 46Z1913, *Ephydra* 30M125. North and Middle Europe, Silesia.

punctatonervosa Fall. 44S247, 53W260, 60L25, 64S252, 96B188, *Notiphila* 13F254, 23F12, 46Z1921, *Ephydra* 30M123. North and Middle Europe, Silesia.

punctulata. See **Axysta cesta.**

sexmaculata Beck. 96B191, 96S291, *Ephydra interstincta* 30M122, 35M539, *Hydrina maculipennis* 30RD795. North and Middle Europe.

stictica Meig. 60L25, 64S253, 96B189, *Ephydra* 30M121. Germany, Silesia.

2. **vittipennis** Zett. 44S250, 46Z1924, 60L26, 64S253, 96B193, *Notiphila* 38Z718. Europe.

HYADINA Haliday.

North American Species.

1. Third antennal joint reddish, infuscated toward the tip..... .....*gravida* Löw.

   Third antennal joint black above, yellow beneath..... .....*albovenosa* Coquillett.

albovenosa Coq. 00C34, 00S309, 05A627. Georgia, Louisiana.

gravida Lw. 63L325, 72L98, 78OS202, 96B270, 05A627. Sitka.

European Species.

guttata Fall. 30RD795, 44S239, 53W261, 60L27, 64S254, 96B194, 00S2, 00S309, *Ephydra* 30M125, *Notiphila* 13F253, 23F11, 38Z718, 46Z1914. North and Middle Europe.

interrupta. See **Philygria.**

humeralis Beck. 96B195, 96S291. Germany.

nitida Macq. 60L28, 64S254, 96B194, *Ephydra* 35M539, *Notiphila brevicornis* 46Z1912, *guttata* var. *brevicornis* 44S240. North and Middle Europe, Silesia.

scutellata Halid. 39H406, 53W262, 96B195. Ireland, Silesia.

sexmaculata. See **Philygria.**

EPHYDRINAE.

OCHTHERA Latreille. Type *mantis.*

North American Species.

1. Face with impressed black lines radiating from an orbital groove.....*lauta* Wheeler.

   Face without such lines..... 2

North American Species—*Continued.*

2. Face with deep black furrows and dots.....*exsculpta* Löw.
   Face without black furrows and dots..... 3
3. Mesonotum with three dark purple and coppery stripes.....
   .....*cuprilincata* Williston.
   Mesonotum without such stripes..... 4
4. First joint of hind tarsi but little swollen....*mantis* De Geer.
   First joint of hind tarsi much swollen..... 5
5. Tarsi black, face broad.....*rapax* Löw.
   Tarsi red, face narrow.....*tuberculata* Löw.

cuprilineata Will. 96W402, 96S291. St. Vincent.
exsculpta Lw. 62L160, 78OS202, 86W307, 95J338, 96B269, 05A628. Cuba, Florida.
lauta Wheel. 96W121, 96S291, 05A628. Milwaukee (Wis.).
mantis Deg. 62L161, 78OS202, 95GT66, 96W123, 96B269, 96S264, 05A628. Middle States, White Mountains (N. H.), Connecticut to California, Mexico.
rapax Lw. 62L162, 78OS202, 96B269, 05A628. Carolina.
tuberculata Lw. 62L161, 78OS202, 95J338, 96B269, 96W123, 05A628. Illinois, Wisconsin, Florida.

European Species.

2. **mantis** Deg. 1809L348, 35M519, 38Z715, 44S166, 46Z1804, 60L30, 62L161, 64S256, 96B204, *Musca* 1782D61, *manicata* 1798F334, *Macrochira mantis* 30M178, *Tephritis manicata* 05F323, 23F2. Whole of Europe.
   mantispa Lw. 47L273, 60L30, 96B205, *Schembri* 47R29. Italy, Greece, Asia Minor.
   schembri. See **mantispa.**

Other Countries.

chalybescens Lw. 62L14, 96B268. Cape of Good Hope.
humilis Will. 97W6, 97S265. Brazil.
innotata Walk. 60W171, 96B267. Celebes.
praedatoria Lw. 62L14, 96B268. Caffraria.
regalis Will. 97W6, 97S265. Brazil.
rotunda Schin. 68S243, 69D374, 96B273. Nikobara.

OCHTHEROIDEA Williston. Type *atra.*
atra Will. 96W401, 96S291. St. Vincent.

ECTROPA Schiner. Type *viduata.*
viduata Schin. 68S243, 68D374, 96B201. Sydney.

PELINA Haliday. Type *acuca.*

North American Species.

truncatula Lw. 78L198, 78OS202, 78K244, 96B270, 05A628. Texas.

European Species.

aenea Fall. 13F253, 23F11, 46Z1926, 60L30, 64S255, 96B197, *glabricula* 30M124, *Telmatobia* 44S209. Europe.

European Species—*Continued.*

aenescens Stenh. 44S201, 46Z192S, 60L30, 96B198, *aenea* 38Z718, *Mikii* 93S280. Scandinavia, England, Austria, Silesia.
guttipennis Stenh. 96B199, *Telmatobia* 44S212. Europe.
nitens Lw. 73L309, 73R427, 96B199. Calabria.
subpunctata Beck. 96B198, 96S291. Dalmatia.
ventruosa. See **Lytogaster abdominalis.**

LYTOGASTER Becker. Type *abdominalis.*
abdominalis Stenh. 96B203, *Philygria* 44S238, *Pelina ventruosa* 73L310. Silesia.

DOMINA Hutton. Type *metallica.*
metallica Hutt. 01H90, 01S272. New Zealand.

BRACHYDEUTERA Loëw. Type *argentata.*

North American Species.

argentata Lw. 05A628, *dimidiata* 62L163, 78OS203, 95J338, 96B269, *Notiphila* 56W406. District of Columbia, Florida.
dimidiata. See **argentata.**

European Species.

argentata Walk. 96B201, *dimidiata* 62L163, *Ephydra* 56W407. Europe.
dimidiata. See **argentata.**

HALMOPOTA Haliday. Type *salinaria.*
mediterranea Lw. 60L34, 96B206. Asia Minor.
salinaria Bouche. 56W346, 60L34, 64S260, 96B205, *Ephydra* 34B99. England, Germany, Silesia.

PARYDRA Stenhammar.

North American Species.

1. Scutellum with conical warts 2
   Scutellum without conical warts 5
2. Scutellum with one wart, apex not bearing a spine 3
   Scutellum with two warts, apices with spines 4
   Scutellum with four warts ..... *quadrituberculata* Löw.
3. Abdomen subopaque, tips of femora, base and tips of tibiæ, and metatarsi dark reddish ..... *imitans* Löw.
   Abdomen black, legs without reddish coloring ..... *unituberculata* Löw.
4. Tubercles exceedingly small, hairing of face snow white ..... *pinguis* Walker.
   Tubercles not unusually small, hairing of face not white ..... *bituberculata* Löw.
5. Face nearly perpendicular ..... *breviceps* Löw.
   Face more or less oblique 6
6. Clypeus and cheeks excessively narrow ..... *paullula* Löw.
   Clypeus and cheeks not excessively narrow 7
7. Second longitudinal vein with a branch near its end 8
   Second longitudinal vein without such branch 10

North American Species—*Continued.*

8. Fourth longitudinal vein with a small but very distinct gray fringe near its apex, third with a similar spot less distinctly visible.....*appendiculata* Löw.
   Third and fourth longitudinal veins without such markings.... 9
9. Wings with seven rather large hyaline spots...*abbreviata* Löw.
   Wings with five hyaline spots.....*varia* Löw.
10. Wings brownish with five hyaline spots, cross veins brown.... .....*aurata* n. sp.
    Wings hyaline, cross veins blackish.....*limpidipennis* Löw.

abbreviata Lw. 61L357, 62L168, 65L97, 78OS203, 96B269, 05A629. Pennsylvania.

appendiculata Lw. 78L202, 78OS203, 78K244, 96B270, 05A629. Texas, California.

aurata n. sp. Southern California.

bituberculata Lw. 62L165, 78OS203, 96B269, 05A629. Middle States, New Jersey.

breviceps Lw. 62L167, 78OS203, 96B269, 05A629. Middle States.

imitans Lw. 78L201, 78OS203, 78K244, 96B270, 05A629. Massachusetts.

limpidipennis Lw. 78L201, 78OS203, 78K244, 96B270, 05A629. District of Columbia.

paullula Lw. 62L167, 78OS203, 96B269, 00C462, 05A629. Middle States, Alaska.

pinguis Walk. 78L199, 78OS203, 78K243, 05A629, *Ephydra* 56W409, 96B266. District of Columbia, Texas, New Jersey.

quadrituberculata Lw. 62L165, 64S258, 78OS203, 95J338, 96B269, 05A629. Middle States, Florida.

unituberculata Lw. 78L200, 78OS203, 78K244, 96B270, 05A629. District of Columbia.

varia Lw. 63L326, 65L100, 78OS203, 96B270, 05A629. Sitka.

European Species.

affinis. See **fossarum.**

aquila Fall. 44S187, 46Z1819, 60L32, 64S259, 64D559, 96B211. *Ephydra* 23F4, 30M117, 35M537, 38Z716, North and Middle Europe, Silesia.

bicuspidata Kars. 81K15, 81K253. Porto Allegre.

coarctata Fall. 44S189, 46Z1821, 60L33, 64S258, 96B214, *Ephydra* 23F4, *rufitarsis* 30M126, 35M356, *stagnicola* 30RD799, *hecate?* 53H263. Whole of Europe, Silesia.

cognata Lw. 60L32, 96B212. Prussia, Sicily.

fossarum Halid. 33H175, 60L32, 64S260, 96B211, *affinis* 44S192, 46Z1824. North and Middle Europe, Silesia.

furcata. See **quadripunctata.**

littoralis Meig. 30M116, 60L33, 64S259, 96B214. Prussia, Germany, Silesia.

nigritarsis Strobl. 93S280, 93S321, 96B215. Styria.

nubecula Beck. 96B212, 96S291. Prussia, Silesia.

obliqua Beck. 96B215, 96S291. Crete, Italy.

pubera Lw. 60L32, 96B210. Sicily, Calabria.

European Species—*Continued.*

pusilla Meig. 30M126, 60L32, 64S259, 96B211, *Ephydra infecta* 33H175, *nasuta* 44S192, 46Z1825. North and Middle Europe, Silesia.

quadripunctata Meig. 30M117, 38Z716, 46Z1822, 60L33, 64S258, 96B214, *furcata* 44S190. North and Middle Europe, Silesia.

undulata Beck. 96B213, 96S291. Russia, Berlin.

Other Countries.

bucculenta Lw. 62L14, 96B268. Caffraria.

humilis Will. 97W7, 97S266. Brazil.

EPHYDRA Fallen. Type *riparia.*

North American Species.

1. Thorax lemon yellow.....*lutea* Wiedmann.
   Thorax ashy, with slight greenish reflection..... 2
   Thorax black or brownish black..... 3
   Thorax dark green..... 8
   Thorax metallic or coppery green..... 11
2. Thorax with three broad vittæ, front brassy green..*cinerea* n. sp.
   Thorax without vittæ, front dark bluish.....*hians* Say.
3. Wings except along veins blackish or smoky..... 4
   Wings gray or hyaline..... 5
4. Front except the lateral margins, shining, slightly greenish.... .....*californica* Packard.
   Front opaque velvety black.....*pygmaea* Williston.
   Front grayish white, dusted with brownish..*thomae* Wiedmann.
5. Thorax dull..... 6
   Thorax shining..... 7
6. Abdomen shining.....*brevis* Walker.
   Abdomen not shining.....*tarsata* Williston.
7. Legs piceous .....*lata* Walker.
   Legs pale yellow.....*nana* Walker.
8. Third antennal joint with a lateral hair..... 9
   Third antennal joint without a lateral hair..... 10
9. Wings clouded with blackish gray.....*atrovirens* Löw.
   Wings grayish hyaline, not clouded.....*pilicornis* Coquillett.
10. Thorax opaque.....*obscuripes* Löw.
    Thorax shining.....*austrina* Coquillett.
11. First joint of front tarsi incrassated.....*crassimana* Löw.
    First joint of front tarsi not incrassated..... 12
12. Third antennal joint minute, sunken in the head..... .....*halophila* Packard.
    Third antennal joint not minute, not sunken in the head.... 13
13. Antennæ dark brown, arista with short pectinations..... .....*millbrae* n. sp.
    Antennæ black, arista with long pectinations...*subopaca* Löw.

Note.—*E. gracilis* described in larval stages only.

Note.—*oscitans* (Walker) certainly differs from all others of this genus in the markings of the wings, and if in this genus at all probably belongs near *pygmaea* or *thomae*, from which it differs in that the front is dark brown.

North American Species—*Continued.*

atrovirens Lw. 62L169, 78OS203, 96B269, 05A629. Middle States.
austrina Coq. 00C36, 05A629. Georgia, Florida.
brevis Walk. 57W233, 78OS203, 96B268, 05A629. United States.
californica Pack. 71P103, 71R397, 84K266, 84W90, 05A629. California, Nevada.
cinerea n. sp. Southern California.
crassimana Lw. 65L182, 65L88, 65D664, 78OS200, 96B270, 05A629. Mexico.
gracilis Pack. 71P105, 71R397, 91S235, 05A629. Great Salt Lake (Utah).
halophila Pack. 68P46, 69D444, 78OS203, 96B270, 05A629. Illinois.
hians Say. 30S188, 83S371, 83K250, 83P976, 78OS200, 96B270, 05A630. Mexico.
lata Walk. 57W233, 96B268, 05A630. United States.
lutea Wied. 30W593, 96B266, 05A630. West Indies.
millbrae n. sp. Millbrae (California).
nana Walk. 57W234, 95J339, 96B268, 05A630. United States.
obscuripes Lw. 66L50, 66D512, 72L92, 78OS200, 96B270, 96S290, 05A630. Massachusetts.
octonotata. See **Scatella.**
oscitans Walk. See **Ilythea** and **Scatella.**
pentastigma. See **Scatella.**
picca. See **Scatella.**
pilicornis Coq. 02C184, 02S264, 05A630. Florida.
pygmaea Will. 96W402, 96S290, 05A630. St. Vincent.
striata. See **Scatella.**
subopaca Lw. 64L98, 64D559, 65L99, 78OS200, 95J339, 96B270, 05A630. Connecticut, New Jersey, Florida.
tarsata Will. 93W257, 93S320, 05A630. Owens Valley (California).
thomae Weid. 30W593, 96B266, 05A630. St. Thomas (West Indies).

European Species.

aquilla. See **Parydra.**
argentata. See **Brachydeutera.**
argyrostoma. See **Scatella sorbillans.**
attica Beck. 96B222, 96S290. Greece.
aurata. See **micans.**
beckeri (new name) *obscuripes.* 96B222. Sarepta.
bivitatta Lw. 60L35, 96B219. Prussia, Sicily.
breviventris Lw. 60L37, 64S261, 96B219. Southern Europe.
cribrata. See **Scatella.**
fenestrata. See **Scatophila despecta.**
flavescens. See **Scatella lutosa.**
flaviceps. See **Philygria.**
flavipennis. See **Scatella aestuans.**
gramium. See **Scatella quadrata.**
guttata. See **Hyadina.**
halophila. See **riparia.**

European Species—*Continued.*

hecate. See **Parydra coarctata.**
infecta. See **Parydra pusilla.**
longipennis. See **Teichomyza.**
macellaria Egg. 62E779, 64S262, 96B220. Europe, Southern Russia.
micans Halid. 33H175, 60L36, 64S261, 96B218, *aurata* 44S167, 46Z1810, *riparia* 23F4. Whole of Europe, Silesia.
nasuta. See **Parydra pusilla.**
nubilipennis. See **Scatella sibilans.**
obscuripes. Preoccupied, see **beckeri.**
ochrostoma Brul. 35B689, 96B224. Europe.
opaca Lw. 56L55, 96B222. Egypt, Southern Europe.
pinguis. See **Parydra.**
punctinervosus. See **Philygria.**
quadrata. See **Scatella.**
riparia Fall. 13F246, 23F3, 30M117, 38Z715, 44S169, 46Z1807, 53W268, 60L35, 64S262, 96B221, *salina* 43H228, *halophila* 44H203. North coast of Europe. See also **micans** and **Caenia fumosa.**
rufitarsus. See **Parydra coarctata.**
salina. See **riparia.**
salinae Zett. 46Z1912, 60L36, 96B219. North and Middle Europe.
salinaria. See **Halmopota.**
sexmaculata. See **Philygria.**
Scholtzi Beck. 96B220. Silesia, Poland.
stagnalis. See **Scatella** and **Scatophila despecta.**
stagnicola. See **Parydra coarctata.**
stenhammari. See **Scatella.**
stictica. See **Philygria.**

Other Countries.

aquaria Hutt. 01H90, 01S273. New Zealand.
australis Walk. 56W409, 96B266. Van Dieman's Land.
bispinosa. See **Beckeriella.**
borboroides Walk. 60W171, 96B267. Celebes.
caesia v. d. Wulp. 83W58, 83K251, 96B271. Argentina.
ciligena Rond. 68R32, 68D374. Buenos Ayres.
gilvipes Coq. 01C377, 01S272. Galapagos.
maculicornis Walk. 60W171, 96B267. Celebes.
margaritata Wied. 30W593, 96B266. Egypt.
ochropus Thoms. 68T592, 70V442, 96B271. Montevideo.
pictipennis Wied. 30W593, 64D559, 96B266. Cape of Good Hope.
pleuralis Thoms. 68T591, 70V442, 96B271. Manila.
prionoptera Thoms. 68T590, 70V442, 96B271. Patagonia.
taciturna Walk. 60W169, 96B267. Amboyna.
urmiana Gunth. 99G415, 99S239. Northwest Persia.

SCATOPHILA Becker. Type *caviceps.*

North American Species.

hamifera Beck. (See "University Collection.") Alameda (California).

European Species.

caviceps. Sten . 96B240, 96S292, *Scatella* 44S269, 46Z1837, 60L42, 64S265. Scandinavia, Germany, Silesia.

contaminata Stenh. 96B240, *Scatella* 44S185. Sweden, Silesia.

cribrata. See **Scatella.**

despecta Halid. 96B241, *Scatella* 39H409, 60L43, 64S267, *Ephydra stagnalis* 23F5, *fenestrata* 44S181, 46Z1831. North and Middle Europe, Silesia.

halterata Beck. 96B245, 96S292. Kohlfurt, Silesia.

2. **hamifera** Beck. 96B242, 96S292. Norway.

laevigata Lw. 96B243, *Scatella* 60L44. Silesia.

pumilio Lw. 96B244, *Scatella* 60L44, 64S267. Silesia.

quadrilineata Strobl. 00S4, 00S310. Spain.

signata Lw. 96B241, *Scatella* 60L43. Sicily, Hungary.

tetra Beck. 96B244, 96S292. Löw's Collection (probably Silesia).

unicornis Czer. 00C205, 00S310. Austria.

variegata Lw. 96B243, *Scatella* 60L43, 64S267. Silesia, Dorpat.

PELOMYIA Williston. Type *occidentalis.*

occidentalis Will. 93W258, 93S321, 96B274, 00C461, 05A628. Monterey (California), Sordova (Alaska).

TEICHOMYZA Macquart. Type *fusca.*

fusca Macq. 35M535, 60L45, 64S268, 86G160, 86S312, 90H239, 90S290, 96B206, *Scatella urinaria* 30RD6, *Ephydra longipennis* 38M382. England, France, Germany, Italy, Silesia.

SCATELLA Robineau-Desvoidy. Type *stagnalis.*

North American Species.

1. Face in profile almost perpendicular, decidedly haired and ciliated.....*stagnalis* Fallen.
   Face not unusually perpendicular, hairing not pronounced.... 2
2. Thorax, coxæ, femora and tibiæ whitish cinereous, wings irregularly streaked with whitish hyaline..*mesogramma* Löw.
   Little or none of the body whitish cinereous, wings usually with definite spots..... 3
3. Spots of the wings hyaline or whitish..... 4
   Spots of the wings brown..... 5
4. Wings with four white spots..... 7
   Wings with five white spots..... 9
   Wings with seven or eight white spots..... 10
   Wings with ten white spots.....*striata* Walker.
5. Two large brown spots between the first cross vein and the point of the wing beyond the third longitudinal.....
   .....*quadrata* Fallen.
   Three or more brown spots beyond the third longitudinal and behind the first cross vein..... 6
6. Base of the tarsi black.....*stenhammari* Zett.
   Base of the tarsi more or less reddish.....*scjuncta* Löw.

North American Species—*Continued.*

7. Wing with a small pitchy spot at the tip of the first longitudinal.....*picea* Walker.
   Wings without such spot..... 8
8. Body ash gray.....*favillacea* Löw.
   Body olive green.....*triscta* Coquillett.
   Body brown.....*octonotata* Walker.
9. Head and chest blackish opaque, densely bluish-gray pruinose .....*setosa* Coquillett.
   Head and chest blackish with olivaceous pruinosity..... .....*pentastigma* Thomson.
   Head and chest yellowish cinereous.....*obsoleta* Löw.
   Head and chest ferrugineus.....*repleta* Walker.
10. Abdomen flecked with white laterally...*cribrata* Stenhammar.
    Abdomen not flecked with white.....*lugens* Löw.

cribrata Stenh. 00L303, 05A630. Greenland.

favillacea Lw. 62L170, 78OS203, 96B269, 05A630. Middle States, New Jersey.

lugens Lw. 62L171, 78OS203, 95J339, 96B289, 05A630. Middle States, Florida.

mesogramma Lw. 69L42, 69D444, 72L74, 78OS203, 96B270, 05A630. Newport (R. I.).

obsoleta Lw. 62L172, 65L98, 78OS204, 96B269, 05A630. Washington (D. C.).

octonotata Walk. 05A630, *Ephydra* 49W1106, 96B267. Martin Falls (Canada).

oscitans Walk. See **Ilythea** and **Ephydra.**

pentastigma Thoms. 05A630, *Ephydra* 68T591, 70V442, 78OS204, 96B271. California.

picea Walk. 05A630, *Ephydra* 49W1105, 78OS204. 96B266. Martin Falls (Canada).

quadrata Fall. 23F5, 64L317, 64S265, 78OS204, 96B270, 05A630. North America.

repleta Walk. 05A630, *Notiphila* 49W1099, 96B266. Martin Falls (Canada).

sejuncta Lw. 63L326, 65L99, 78OS204, 96B271, 05A631. Sitka (Alaska).

setosa Coq. 00C462, 00S310, 05A631. Alaska.

stagnalis Fall. 45S169, 72H97, 78OS204, 86G162, 86S312, 96B271, 96S264, 98L303, 00C462, 00H593, 05A631, *obscura* 96W403. Greenland, Alaska, New Jersey, Georgia, Arizona, St. Vincent, Montreal, White Mountains (N. H.).

stenhammari Zett. 78OS204, 96B271. North America. North America.

striata Walk. 05A631, *Ephydra* 49W1107, 96B267. Martin Falls (Canada).

triseta Coq. 02C184, 02S265, 05A631. Arizona.

Note.—*oscitans*, if a **Scatella**, is probably most closely related to *S. striata*, from which it differs in the absence of five hoary stripes on the chest.

European Species.

aestuans Halid. 33H176, 64S266, 96B233, *Ephydra flavipennis* 44S173, *gilva* 60L41. Asia Minor, Southern Hungary.

callosicosta Bezzi. 95B70, 95S345, 96B232. Calabria, Orsova, Silesia.

contaminata. See **Scatophila**.

crassicosta Beck. 96B234, 96S291. Sylt Island.

2. **cribrata** Stenh. 60L42, *Scatophila* 64S265, 96B240, *Ephydra* 44S269, 46Z1835. North and Middle Europe.

defecta Halid. 33H174, 46Z1813, 60L38, 96B236, *Caenia* 53W265. Triest.

despecta. See **Scatophila**.

dichaeta Lw. 60L40, 96B228. Harz, Sylt Island, Sweden.

indistincta Beck. 96B231, 96S291. Hungary.

laevigata. See **Scatophila**.

lutosa Halid. 33H176, 60L42, 64S266, 96B236, *Ephydra flavescens* 44S175, 46Z1830. North and Middle Europe, Silesia.

pilosigenis Beck. 96B229, 96S291. East coast of Europe.

pumila. See **Scatophila**.

2. **quadrata** Fall. 30M119, 39H410, 44S182, 46Z1840, 60L40, 64S265, 96B230, *Ephydra* 23F5, *graminum* 33H176. Whole of Europe, Silesia. See also **stenhammari**.

quadrisetosa Beck. 96B229, 96S291. Norway.

sibilans Halid. 33H175, 60L40, 64S265, 96B228, *Ephydra nubilipennis* 44S180. North and Middle Europe, Silesia.

signata. See **Scatophila**.

silacea Lw. 60L41, 64S266, 96B233. Silesia.

sorbillans Halid. 33H176, 60L41, 64S265, 96B231, *Ephydra argyrostoma* 44S176, 46Z1831. Whole of Europe, Silesia.

2. **stagnalis** Fall. 44S178, 46Z1827, 60L42, 64S266, 96B235, *Ephydra* 13F248, 23F5. North and Middle Europe, Silesia.

2. **stenhammari** Zett. 60L40, 64S266, 96B230, *quadrata* 44S183, *Ephydra stenhammari* 46Z1842. North and Middle Europe, Silesia.

urinaria. See **Teichomyza**.

variegata. See **Scatophila**.

Other Countries.

hawaiiensis Grim. 01G49, 01S274. Oahu (Sandwich Islands).

3. **stagnalis** Fall. 97W5, 97S266. Brazil.

CAENIA Robineau-Desvoidy. Type *palustris*.

North American Species.

1. Front black, clothed with long bristles.....*spinosa* Löw.
. Middle of front bronze green, partially covered with short hairs, but without long bristles.....*bisetosa* Coquillett.

bisetosa Coq. 02C183, 02S263, 05A631. Utah, California.

spinosa Lw. 64L99, 65L100, 64D559, 78OS204, 95J339, 96B271, 05A631. New York, Florida, New Jersey.

European Species.

beckeri Kuntze. 97K154, 97S265. Rome.
carricola. See **palustris.**
fumosa Stenh. 44S171, 46Z1813, 60L38, 64S264, 96B207, *Ephydra riparia* 23F4. North and Middle Europe, Silesia.
obscura Meig. 30M115, 53W265, 60L38, 96B208. Germany, England.
palustris Fall. 23F4, 30M115, 35M530, 38Z716, 44S172, 46Z1815, 60L38, 64S264, 96B207, *carricola* 30RDS00. Whole of Europe, Silesia.

NOMBA Walker. Type *tecta*.
tecta Walk. 60W169, 96B267. Celebes.

CANACENAE.

CANACE Haliday. Type *nasica*.
nasica Halid. 39H411, 53W269, 60L29, 64S269, 74LS0, 96B247. Ireland. See also **ranula.**
ranula Lw. 74LS1, 74R449, 87S297, 87G1, 96B247. *nasica* 55H64. North coast of England, Germany.
salonitana Strobl. 00S63, 00S308. Salona.
snodgrassi Coq. 01C378, 01S272. Galapagos.

GENERA APPEARING ONLY IN THE SYNONYMY.

Diasemocara.
nigrotaeniata. See **Psilopa** and **Ephygrobia roderi.**
Drosophila.
pollinosa. See **Paratissa.**
Glabrinus.
mororum. See **Gymnopa subsultans.**
Hydrina.
guttata. See **Hyadina.**
Keratocera.
palustris. See **Notiphila cinerea.**
tarsata. See **Notiphila.**
Macrochira.
mantis. See **Ochthera.**
Mosillus.
arcuatus. See **Gymnopa subsultans.**
Musca.
manicata. See **Ochthera mantis.**
Telmatobia.
aenea. See **Pelina.**
Tephritis.
manicata. See **Ochthera mantis.**
Ulida.
arcuata. See **Gymnopa subsultans.**

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COLLEGE OF AGRICULTURE, AGRICULTURAL EXPERIMENT STATION
ENTOMOLOGY
Vol. 1, No. 3, pp. 199-216 February 2, 1916

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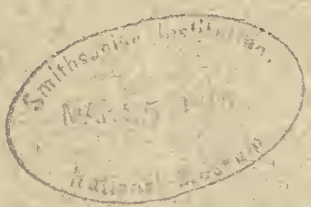

UNIVERSITY OF CALIFORNIA PRESS
BERKELEY

UNIVERSITY OF CALIFORNIA PUBLICATIONS
TECHNICAL BULLETINS
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SYNOPTICAL KEYS TO THE GENERA OF THE NORTH AMERICAN MIRIDAE

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The following keys cover all but eight of the genera of the Miridae thus far recorded from America north of Mexico. These eight genera were omitted on account of the want of material for study or because their occurrence in this country is a matter of much uncertainty. Dr. Reuter's great work on the Capsidae of Europe (*Hemiptera Gymnocerata Europae*, 5 vols., 1878–1896) and his later studies in the North American fauna have formed the foundation for the present paper, although the keys given here are for the most part original. I have found it impossible to work out his subfamilies of 1910 in a satisfactory analytical form, and, while accepting them in my catalogue of our Hemiptera, I have ignored them in the preparation of these keys, using only his tribes, or divisions as he terms them. In addition to these tribes I have found it both practicable and useful to establish groups of a lower category in two of the larger tribes which have been denominated divisions with the termination *-aria*. All synonymy has been omitted here, but it will be given in the catalogue.

One fact comes out plainly in these studies: that certain characters that are useful for diagnosis in one group may fail in another. This arises from the well-known fact that a character once discarded in the evolution of a group is never revived. Thus we find that the hamus, or vestigial vein, found in the wing-cell

in most of the Phylaria, is apparently always absent in the Orthotylini where it seems to have been discarded, but in the Oncotylaria, which is intermediate between these groups, it may be either present or absent in the same genus, possibly in the same species or individual.

The characters of the arolia present a similar case. Their form seems to be constant for each tribe but in any, at least of the larger ones, it may be entirely absent in certain genera. I would not, however, consider the arolia a vestigial character as is the hamus in the wing-cell.

In these keys I have attempted to arrange the tribes and genera in what seems to me to be the correct descending order, but here there certainly is a large field for investigation and many changes will probably have to be made. The claspers, or genital hooks, of the male form excellent specific characters in many cases, but there are groups of species here and there in which these hooks exhibit scarcely any appreciable differences between what are undoubtedly good species.

The following are the eight genera omitted from the keys: *Neocapsus* Dist., *Pallacocoris* Reut., *Neoborops* Uhler, *Eccritotarsus* Stal, *Teleorhinus* Uhler, *Cyllocoris* Hahn, *Orthocephalus* Fieb., *Microsynamma* Fieb.

As a matter of convenience the following terms are explained here.

Arolia.—The pulvillae between the base of the tarsal claws, sometimes free, sometimes united with the claws beneath.

Buccula.—A narrow plate lying either side of the base of the rostrum; rarely used in the Capsidae.

Callosities.—A more or less elevated area on either side of the anterior lobe of the pronotum, usually distinguished by an impressed bounding line, at least posteriorly.

Cheeks or *gena.*—The two sclerites below the eyes and between the clypeus and gula. Between them is frequently a narrow segment called the *lora.* The inner or upper cheeks may be nearly flat or at times considerably elevated or tumid.

Clavus.—The inner area of the elytra next to the scutellum and separated from the corium by the claval suture. It is usually long-triangular in form, with its apex near the base of the membrane.

Clypeus or *tylus.*—The median lobe of the head below the front and reaching to the base of the rostrum.

Collar or *collum.*—The narrow anterior margin of the pronotum. Generally separated from the disk of the pronotum by an impressed line which may or may not be continued over the side.

Corium.—The main portion of the elytra lying exterior to the clavus; its outer margin being formed by the costa.

Cuneus.—A triangular piece, joined by a suture to the apex of the corium.

Facial angle.—The angle between the line of the buccnlae and that of the clypeus when viewed from the side.

Fracture.—The notch between the apex of the corium and the base of the cuneus on the costal margin of the elytra.

Front.—The front of the head between the eyes, below the vertex and above the clypeus.

Gula.—The throat, or lower surface of the base of the head lying beneath the rostrum.

Lorae.—The narrow segment lying between the upper and lower cheeks at the base of the rostrum.

Membrane.—The membranous apical portion of the elytra. It carries a looped nervure at base forming one large areole and usually a second smaller one next the apex of the cuneus.

Scutellum.—The basal lobe is usually convex and separated from the apical by a suture. This basal lobe is often more or less covered by the base of the pronotum and in using this character allowance must be made for the depression of the pronotum.

Tylus.—Same as clypeus.

Vertex.—The basal portion of the superior surface of the head between the eyes. It merges insensibly into the base of the front.

Vestiture.—The covering of hairs on the surface of the body. These hairs may be soft or stiff, or they may be flattened and scale-like, and are often deciduous and very easily rubbed off.

Xyphus (prosternal).—The triangular piece on the prosternum between the bases of the anterior coxae.

In the Phylaria three new genera have been established for which there are as yet no described species, and they are therefore invalid here, but they will soon be validated by the publication of species. These genera are: *Leptotylus*, *Oligotylus*, and *Strophopoda*. One hundred and twenty-five genera are treated of here which, with the eight omitted genera, make a total of one hundred and thirty-three genera recorded from America north of Mexico.

The following is a fairly close translation of Reuter's key to his subfamilies of 1910:

1 (16). Membrane biareolate, or with one areole distinctly dilated at apex, very rarely without an areole but with several irregular longitudinal veins more or less distinct. Elytra with a distinct cuneus which very rarely becomes confluent with the corium.

2 (3). Arolia large, free, approximate at base between the claws, toward their apex very distinctly divaricate and frequently dilated. **9. Mirinae**

3 (2). Arolia differently formed or wanting.

4 (5). Membrane distinctly pilose. Claws destitute of arolia. **8. Bothynotinae**

5 (4). Membrane glabrous.

6 (7). Pronotum without a collar, but with its apical area gibbous-convex, anteriorly frequently more or less produced above the vertex; always roundedly produced posteriorly but not surpassing the sides, the lateral margins attaining the apical. Arolia short, united to the claws or wanting. First tarsal joint longer than the second. **6. Ambraciinae**

7. (6). Pronotum with or without apical collar; destitute of a gibbous posteriorly rounded apical area.

8 (9). Arolia wanting. First joint of hind tarsi long or very long, rarely not longer than the second. Tibiae frequently mutic and very distinctly more slender toward its apex. Wing-cell with the hamus wanting or very rudimentary. **7. Cylapinae**

9 (8). Arolia present, rarely wanting, in this case with the first joint of the tarsi short, or the wing-cell with a distinct hamus, or the body constricted at the middle. First joint of the tarsi very rarely long, in this case the cell of the wing with a hamus or the arolia present. Tibia very attenuated toward its apex.

10 (11). Apical joint of the tarsi more or less distinctly incrassate, rarely sublinear. Arolia laminate, rarely short, frequently large, always approximate to or connate with the claws. Tibiae always destitute of spines. Lorae confluent with the cheeks. Cell of the wings without a hamus. **5. Bryocorinae**

11 (10). Apical joint of the tarsi linear, rarely a little thicker toward its apex, in this case the arolia free and connivent at apex. Tibiae frequently distinctly spinose.

12 (13). Prothorax with an annular collar at apex, in brachypterous females sometimes obsolete above in the middle. Arolia none, or with the arolia varying in length and closely approximated to the claws with which they are connate, at least at base, frequently for their whole length. Lorae linear, well distinguished on either side. **4. Macrolophinae**

13 (12). Prothorax without an apical collar, sometimes with the apical margin slenderly depressed, in this case with the arolia free and connivent at apex.

14 (15). Arolia free, slender, parallel or connivent at apex, very rarely none, in this case the wing-cell destitute of a hamus, or the body constricted at the middle, or the last two joints of the antennae thicker than the others. **3. Heterotominae**

15 (14). Arolia connate with the claws, very rarely free, in this case closely approximated to them, sometimes expanded at apex with the claws minute, falciform; frequently narrowly laminate, rarely none, in this case the wing-cell furnished with a hamus. **2. Phylinae**

16 (1). Membrane with but one areole, the vein mostly parallel with the suture. Elytra destitute of an embolium and cuneus. Prothorax without an apical stricture. First tarsal joint long. Arolia none. **1. Lygaeoscytinae**

Of these, the subfamily Lygaeoscytinae is Australian; the subfamily Bothynotinae is confined to the Old World; the subfamily Phylinae is equivalent in our fauna to my Phylini, Bryocorinae to my Bryocorini, and Cylapinae to my Cylapini. Reuter's subfamily Heterotominae is the same as my Orthotylini, but his typical division Heterotomaria was first founded as Litosomidae by Douglas and Scott in 1865; but their genus *Litosoma* being a straight synonym of *Orthotylus* Fieb., the tribe, or division of Reuter, must be called Orthotylini and the subfamily Orthotylinae. Reuter's Macrolophinae embrace my Dicyphini (Macrolopharia Kirk., 1906 is antedated by Idolocoridae Dougl. and Scott. 1865, the typical genus *Idolocoris* Dougl. and Scott, 1865, being a synonym of *Dicyphus* Stal, 1858), and my Hallodapini which is equivalent to Cremnocephalaria Reut. (first established as Eroticoridae Dougl. and Scott, 1865, the typical genus *Eroticoris* Dougl. and Scott being a synonym of *Hallodapus* Fieb., 1858). Lastly Reuter's Mirinae include my Myrini, Capsini and Horistini; the latter, termed Restheniaria by Reuter, was first distinguished as Lopidae by Douglas and Scott in 1865, their *Lopus* being equivalent to *Horistus* Fieb., 1861. It will be noticed that Reuter has entirely ignored the work of Douglas and Scott, who were the first to break up the great family Capsidae into smaller divisions. That their divisions were sometimes made too limited in scope and were termed families is no reason for ignoring them entirely. Reuter uses the termination *-ina* for his subfamilies, which I have changed to *-inae* to make them conform to modern usage.

KEY TO THE TRIBES

Apical margin of pronotum without a collar, swollen or elevated in a hood above the base of the vertex ..... **Clivinemini**

Apical margin of pronotum not swollen or elevated in a hood above the base of the vertex 1

1. Third tarsal joint thickened toward its apex; membrane in our genera uniareolate ..... **Bryocorini**

— Third tarsal joint linear, or nearly so 2

2. Pronotum with a distinct apical collar, or with a flattened anterior margin simulating a collar 3
— Pronotum without a collar 9
3. Pronotal collar convex, separated from anterior disk by a distinct incised line 4
— Pronotal collar flat, without an incised line behind it, or wanting; body elongated, often linear 8
4. Head viewed from above short, vertical, produced below the eye for nearly twice the length of the eye; antennae long and slender, much longer than the entire body, inserted the length of the clypeus above its base; basal joint of the tarsi as long as the following two together; arolia wanting; vertex deeply sulcate; pronotal collar very slender ..... **Cylapini**
— Head not greatly produced below the eye; antennae rarely longer than the entire body, inserted about on the line of the base of the clypeus; basal joint of the tarsi shorter than the following two taken together 5
5. Rostrum long, passing the middle of the venter; head produced, horizontal or nearly so; tibiae smooth, or with minute pubescence only; tarsi slender, basal point but little shorter than the following two together; arolia wanting ..... **Fulvini**
— Rostrum shorter, scarcely surpassing the hind coxae; tibiae armed with bristles or clothed with longer hair, rarely smooth 6
6. Pronotal collar broad, convex, about as broad as the callosities; tibiae thickly clothed with soft hairs but without rows of stouter bristles; body opaque, black, marked with red or fulvous ..... **Horistini**
— Pronotal collar narrow, convex, often linear, rarely broad; then flat with the body elongated, tibiae smooth and pronotum broadest before the middle 7
7. Body elongated, often linear; base of scutellum usually exposed; tibiae smooth or nearly so; arolia minute and united with base of the claws, or as long as the claws and lying close to them ..... **Dicyphini**
— Body rarely elongated, with the base of scutellum exposed and tibiae smooth or nearly so, arolia in this case free and divergent at apex ..... **Capsini**
8. Tarsi long, first joint longer than the following two together; pronotal collar a mere flattening of the anterior margin, or sometimes wanting; vertex often sulcate; arolia large, free, often clavate ..... **Mirini**
— Tarsi shorter, first joint not longer than the third, usually shorter, pronotal collar often wanting; arolia united with the claws or wanting ..... **Hallodapini**
9. Arolia free, parallel, or converging toward their tips; wing-cell without a hamus ..... **Orthotylini**
— Arolia wanting, or parallel with and usually united to the claws at base, wing-cell normally with a hamus ..... **Phylini**

KEYS TO THE GENERA

Tribe Mirini Douglas and Scott

Head exserted, distinctly narrowed behind the eyes, which are not contiguous to the anterior angles of pronotum; pronotum with a distinct collar 1

Head not obviously exserted, eyes contiguous to the anterior angles of pronotum, or nearly so 2

1. Head strongly exserted, eyes being located at about the middle; median sulcus of the vertex short but distinct.....1. **Collaria** Prov.

— Head little exserted, eyes being located near to the hind margin of the head but distinctly separated from the anterior angles of pronotum; vertex transversely depressed between the eyes, median sulcus nearly or quite obsolete .....2. **Miris** Fabr.

2. Base of pronotum truncated or a little emarginate at the middle..... 3

— Base of pronotum concavely arcuated, leaving the base of scutellum broadly exposed 5

3. Basal lobe of scutellum covered by pronotum.....3. **Stenodema** Lap.

— Basal lobe of scutellum exposed 4

4. Body narrow, elongated; head one-third longer than broad, nearly or quite as long as the pronotum .....4. **Megaloceraea** Fieb.

— Body more ovate; head short, not longer than broad, much shorter than the pronotum .....5. **Mesomiris** Reut.

5. Large areole of the membrane entirely hyaline; head long and pointed, with the median sulcus deep .....6. **Trigonotylus** Fieb.

— Large areole of the membrane, or at least its outer half, opaque punctate; head short, transversely flattened at base, median sulcus obsolete, or nearly so .....7. **Teratocoris** Fieb.

Tribe Horistini n.n.

Head short, vertical, when viewed from the side nearly square at apex, gula almost obliterated; elytra parallel, or the costa regularly and feebly arcuated; second joint of hind tarsi not more than half the length of the first 1

Head a little oblique, when viewed from the side distinctly produced and narrowed toward the apex, gula quite long, oblique; elytra considerably expanded beyond the middle; second joint of hind tarsi nearly or quite as long as the first .....2. **Opisthuria** Reut.

1. Vertex and front more or less convex, front not at all tumidly projecting before the clypeus; sides of pronotum anteriorly carinate only across the incisure separating the collum....1. **Platytylellus** Reut.

— Front tumid, projecting prominently before the base of the clypeus; pronotal margins anteriorly carinate to behind the callosities ..... 3. **Oncerometopus** Reut.

Tribe Capsini Reuter

KEY TO THE DIVISIONS

Body linear, constricted at the middle; pronotum swollen at its middle and as wide there, or wider, than on hind margin....1. **Myrmecoraria**

Body rarely linear and constricted at the middle, pronotum in this case widest behind 1

1. Arolia free, divergent, usually more or less curved and clavate 2
— Arolia absent, their place taken by two parallel setae; membrane often uniareolate; body robust, polished .....5. **Deraeocoraria**
2. Body above impunctate, or with fine aciculate punctures only..... 3
— Body above, or at least the pronotum, coarsely distinctly punctate, polished, callosities prominent .....4. **Capsaria**
3. Form more elongate, parallel or subparallel, cuneus at most but slightly depressed and the fracture small .....2. **Phytocoraria**
— Form more ovate, elytra more distinctly convex, the cuneus strongly deflexed and the fracture deep .....3. **Dichrooscytaria**

Division 1. Myrmecoraria Reut.

Head constricted into a short neck behind the eyes; clypeus prominent, convex, its base distinct from the front; pronotal collar with a distinct incised line behind .....1. **Mimoceps** Uhl.

Head not constricted behind the eyes; clypeus depressed, merged with the front; stricture of pronotal collar evanescent at its middle ....2. **Pithanus** Fieb.

Division 2. Phytocoraria Reut.

Body above opaque and impunctate 1
Body above more or less distinctly polished, sometimes shagreened or aciculate-punctate and almost opaque 4

1. Form linear, constricted at the middle; pronotum produced, almost cylindrical before; vertex sulcate .....1. **Paraxenetus** Reut.
— Body not constricted at the middle, pronotum trapezoidal; vertex not obviously sulcate 2
2. First antennal joint thickened and clothed with flattened hairs ....2. **Neurocolpus** Reut.
— First antennal joint without flattened hairs..... 3
3. Hind femora linear, terete or nearly so .....4. **Ecertobia** Reut.
— Hind femora ligulate, flattened, broadest near the base and tapering from middle to apex .....3. **Phytocoris** Fall.
4. Head not or scarcely vertical, when viewed from the side distinctly narrowed below antennae; gula oblique 5
— Head vertical, thick and cylindrical below antennae; gula nearly or quite parallel with tylus 10
5. Second antennal joint strongly clavate, fusiform, more tapering toward base .....10. **Garganus** Stal.
— Second antennal joint sometimes moderately thickened but not strongly clavate 6
6. Vertex not sulcate at base 7
— Vertex sulcate at base 8
7. First joint of hind tarsi shorter than the second.....9. **Ganocapsus** Van D.
— First joint of hind tarsi much longer than the second....8. **Stenotus** Reut.

8. Face opaque, distinctly obliquely striate; sulcus conspicuous; clypeus not at all polished; callosities inconspicuous.....5. **Creontiades** Dist.
— Face polished, without distinct striae; sulcus inconspicuous; clypeus polished; callosities conspicuous 9
9. Sides of pronotum carinate; collar broad; head subhorizontal; eyes small, oblique .....6. **Allorhinocoris** Reut.
— Sides of pronotum ecarinate, rounded; collar very slender; head nearly vertical and thick at apex, extending but little below the large vertical eyes .....7. **Adelphocoris** Reut.
10. Second antennal joint clavate, clavate portion occupying the apical third and strongly flattened and sulcate above; vertex without a sulcus; surface polished, nude .....11. **Ectopiocerus** Uhler
— Second antennal joint linear, not at all clavate; surface above clothed with a close pubescence 11
11. Whole upper surface closely, minutely shagreened, giving the insect an opaque aspect; vertex sulcate at base; antennae inserted much below the eyes .....13. **Thyrillus** Uhler
— Upper surface more polished; base of vertex with a transverse groove but scarcely prolonged at the middle in a sulcus; antennae inserted close against the lower angle of the eyes .....12. **Irbisia** Reut.

Division 3. Dichrooscytaria Douglas and Scott

Upper surface opaque or nearly so, clothed with short pubescence 1
Upper surface highly polished, nude; form broad-ovate; cuneus strongly deflexed 6
1. Pronotum marked with a pair of round black points, occasionally wanting in specimens not fully colored 2
— Pronotum without the pair of round black points 4
2. Basal joint of antennae terete, or nearly so 3
— Basal joint of antennae strongly compressed, nearly as wide as hind femora .....2. **Lampethusa** Dist.
3. Second antennal joint linear; first joint with but few minute hairs, not, or scarcely, longer than the head .....4. **Calocoris** Fieb.
— Second antennal joint thickened toward the apex; first joint densely pubescent, hairs nearly or quite as long as the thickness of the joint .....3. **Paracalocoris** Dist.
4. Antennae stout, second joint strongly clavate, third and fourth abruptly slender and together scarcely longer than the first; body broad oval, densely sericeous-pubescent; scutellum tumid.... 1. **Pycnocoris** Van D.
— Antennae slender, second joint linear, third and fourth joints together nearly or quite as long as the second 5
5. Head exserted, the small rounded eyes not overlapping pronotal angles; base of clypeus when viewed from above much anterior to the insertion of antennae .....5. **Poeciloscytus** Fieb.
— Head broad and short, closely set against pronotum, the large eyes overlapping its anterior angles; base of clypeus when viewed from above in a line with base of antennae .....6. **Dichrooscytus** Fieb.

6. Rostrum long, reaching at least to intermediate coxae; pronotum with obscure scattering impressed points, but not at all punctate ..... **7. Horcias** Dist.

— Rostrum short, not surpassing anterior coxae; pronotum obscurely punctured ..... **8. Poecilocapsus** Reut.

Division 4. Capsaria Reut.

Vertex sulcate and transversely striate; second joint of hind tarsi much shorter than first and third ..... **4. Platylygus** Van D.

Vertex more or less polished, scarcely striate or sulcate; first and second tarsal joints subequal 1

1. Elytra nearly flat, cuneus at most but moderately deflexed 2

— Elytra more convex, cuneus much deflexed and the fracture deep..... 6

2. First and second antennal joints rather thick, the second linear and scarcely thinner than the first, or in the female slightly attenuated at base and apex 3

— Second antennal joint more or less distinctly thickened toward its apex; sometimes sublinear but then distinctly thinner than joint one 4

3. Base of vertex flattened, hind margin carinate; base of scutellum but little exposed; elytra oblong, parallel ..... **3. Lygidea** Reut.

— Vertex convex, polished, its base ecarinate; base of scutellum broadly exposed; body oval, distinctly broader behind the middle; color red ..... **2. Coccobaphes** Uhl.

4. Third and fourth antennal joints abruptly thinner and together scarcely more than half the length of the second joint, which is linear and moderately thickened but thinner than first ..... **6. Tropidosteptes** Uhl.

— Antennae slender, third and fourth joints setaceous and together at least two-thirds the length of the second 5

5. Form more ovate; sides of the pronotum carinate..... **7. Neoborus** Dist.

— Form more elongated and subparallel; sides of the pronotum ecarinate ..... **8. Xenoborus** Reut.

6. Inner cheeks tumidly convex, forming almost a tubercle beyond base of antennae; second antennal joint clavate; pronotum coarsely punctured; head broad behind and concentric with the anterior margin of pronotum ..... **1. Capsus** Linn.

— Inner cheeks convex but not prominently tumid; second antennal joint but little thicker at apex; pronotum more finely punctured; eyes rounded behind, head not concentric with the anterior margin of pronotum ..... **5. Lygus** Hahn.

Division 5. Deraeocoraria Douglas and Scott

Vertex transversely striate and longitudinally sulcate; second joint of hind tarsi much shorter than first and third 1

Vertex more or less polished, scarcely striate or sulcate; first and second tarsal joints subequal 2

1. Second antennal joint clavate; third and fourth short and thick, fusiform; prosternal xyphus convex, but slenderly margined .... **2. Diplozona** Van D.
— Antennae linear, of nearly equal thickness throughout; second joint scarcely enlarged at apex, third and fourth linear....**1. Cimatlan** Dist.
2. Elytra punctate, not bullate behind; basal joint of hind tarsi not produced below beyond the second 3
— Elytra impunctate, bullate behind, cuneus almost vertical; basal joint of hind tarsi thickened, oblique at apex and attaining the apex of second joint; head nearly vertical, but little produced before the eyes .....**4. Klopicoris** Van D.
3. Head strongly produced and nearly horizontal, surpassing apex of short first antennal joint; second antennal joint thick and very long, nearly linear, longer than the remaining three joints taken together; sides of pronotum ecarinate .....**3. Eurychilopterella** Reut.
— Head less produced, not surpassing middle of basal antennal joint..... 4
4. Sides of pronotum carinate, antennae rather short and slender, apex of the second joint distinctly thickened; membrane often uniareolate; xyphus sometimes convex on the middle .....**5. Camptobrochis** Fieb.
— Sides of the pronotum ecarinate; antennae longer, basal two joints stout, the first surpassing the apex of the head by two-thirds its length, second a little thicker apically.....**6. Deraeocoris** Kirschb.

Tribe Bryocorini Douglas and Scott

Form oblong, more or less elongated, elytra parallel or subparallel..... 1
Form shorter, ovate or subovate 4
1. Eyes on a suberect stylus which is at least as long as the width of the eye .....**9. Hesperolabops** Kirk.
— Eyes sessil, or at most but substylate 2
2. Eyes large, exserted or substylate; callosities convex, oblique, contiguous at middle of pronotum, leaving a transverse triangular punctured area before .....**8. Caulatops** Bergr.
— Eyes smaller, not at all stylate; callosities more transverse, not contiguous at middle of pronotum 3
3. Body opaque, pubescent; second joint of antennae long, about equalling basal width of pronotum .....**7. Dacota** Uhl.
— Body smooth, more or less polished; second joint of antennae short, not longer than width of head .....**6. Sysinas** Dist.
4. Pronotum with a prominent linear collar .....**5. Monolocoris** Dahlb.
— Pronotum without a distinct collar 5
5. Scutellum without a triangular discal impression 6
— Scutellum with a triangular discal impression 7
6. Embolium broadly expanded, about as wide as hind femora; pronotum strongly convex and bullate behind, with three longitudinal impressions .....**4. Pycnoderes** Guer.
— Embolium linear; pronotum convex but not at all bullate or longitudinally impressed behind .....**3. Sixeonotus** Reut.

7. Antennae inserted close to apex of the eye, basal joint very short, one-third shorter than width of front .....2. **Halticotoma** Reut.
— Antennae inserted some distance above apex of the eye, last joint considerably longer than width of vertex and much surpassing clypeus .....1. **Cyrtocapsus** Stal.

Tribe Clivinemi Reuter

Second antennal joint linear; sides of pronotum without a distinct carina .....1. **Clivinema** Reut.
Second antennal joint stout, clavate, apical two short and abruptly slender; sides of pronotum distinctly carinated .....2. **Largidea** Van D.

Tribe Cylapini Reuter

Form oval; head short, vertical; vertex with a deep longitudinal impression; antennae very long and slender, much surpassing tip of membrane; basal joint thickened, fusiform .....1. **Cylapus** Say

Tribe Fulvini Uhler

Body elongated; costa but feebly arcuate; sides of pronotum concavely arcuate, humeral angles prominent .....1. **Fulvius** Stal.
Body broad-oval; costa strongly arcuate; sides of pronotum not at all concavely arcuate, humeri not prominent .....2. **Peritropis** Uhler

Tribe Hallodapini n.n.

Tarsal claws with arolia minute or wanting 1
Tarsal claws with long parallel arolia; females sometimes wingless, formiciform 5
1. Hind margin of pronotum with a median spine, behind which the edge is notched .....1. **Dacerla** Sign.
— Hind margin of pronotum without spine or notch 2
2. Head short, vertical, but little produced below the eyes 3
— Head long, oblique, produced below the eyes for a distance nearly as great as the length of the eye 4
3. Posterior lobe of scutellum tumidly elevated....2. **Cyrtopeltocoris** Reut.
— Posterior lobe of scutellum transversely moderately convex, horizontal .....3. **Sericophanes** Reut.
4. Posterior lobe of scutellum moderately convex, subcarinate; sides of pronotum almost rectilinear, a little curved outward at the humeri .....4. **Closterocoris** Uhler
— Posterior lobe of scutellum tumidly elevated, subconical, as high as base of pronotum .....5. **Cyphopelta** Van D.
5. Second antennal joint clavate .....6. **Orectoderus** Uhler
— Second antennal joint linear .....7. **Coquillettia** Uhler

Tribe Dicyphini Reuter

Hind margin of pronotum rectilinear, or slightly concavely arcuate; head vertical before, when viewed from the side not projecting before eyes; hind margin of callosities located considerably before the middle of the pronotum .....1. **Hyaliodes** Reut.

Hind margin of pronotum concavely arcuate, leaving base of scutellum exposed; head sometimes nearly vertical but then narrowly but distinctly surpassing front line of eyes; hind margin of callosities nearly or quite attaining middle of pronotum 1

1. Head when viewed from the side distinctly produced and oblique; angle of face (angle of tylus and bucculae) subacute; eyes small and oblique, placed at middle of the head .....4. **Macrolophus** Fieb.

— Head vertical or nearly so; apex of head truncated, facial angle a right angle; eyes large and vertical 2

2. Head produced in a distinct neck behind eyes, space behind the eye when viewed from the side about as long as width of the eye .....2. **Dicyphus Fieb.**

— Head scarcely produced behind the eye, forming but a very slender margin there of about the width of pronotal collum ....3. **Engytatus** Reut.

Tribe Orthotylini n.n.

key to the divisions

Head broad with eyes stylate, their inner margins being beyond the pronotal angles .....1. **Laboparia** Reut.

Head sometimes broad but eyes not at all stylate 1

1. Head broad, hind margin sharp, concentric with or overlapping anterior margin of pronotum 2

— Head not unusually broad, not concentric with or overlapping anterior margin of pronotum; eyes rounded behind 3

2. Form broad-oval; hind femora often broad, saltatorial; clypeus distinct from the front .....2. **Halticaria** Kirk.

— Form elongated, body often constricted at the middle; hind femora normal; clypeus depressed and fused with the front ....3. **Pilophoraria** Reut.

3. Apical two joints of antennae not thinner than the second ....4. **Ceratocapsaria** n.n.

— Apical two joints of antennae abruptly thinner than the second, setaceous, or nearly so 4

4. Base of vertex and sides of pronotum sharply carinate; anterior margin of pronotum sometimes distinctly elevated in a ridge by a transverse depression before callosities; body opaque....5. **Lopidearia** n.n.

— Base of vertex and sides of pronotum sometimes more or less carinate; anterior margin of pronotum in this case not at all elevated ....6. **Orthotylaria** n.n.

Division 1 Laboparia Reut.

But one North American genus .....**Labops** Burm.

Division 2. Halticaria Reut.

Antennae long, setaceous, as long as entire body; hind femora greatly flattened, saltatorial .....1. **Halticus** Hahn.

Antennae scarcely longer than elytra; hind femora not greatly widened nor saltatorial .....2. **Strongylocoris** Blanch.

Division 3. Pilophoraria Reut.

Head with eyes little wider than anterior margin of pronotum; sides of pronotum not arcuated; body not constricted at the middle; upper surface ornamented with dots of silvery hairs ..... 1. **Heterocordylus** Fieb.

Head much wider than anterior margin of pronotum; sides of pronotum arcuate; body constricted at the middle; elytra sometimes with transverse lines of silvery hairs 1

1. Second antennal joint distinctly clavate; body constricted at the middle; elytra usually ornamented with transverse lines of pale scale-like hairs ..... 2. **Pilophorus** Hahn.

— Second antennal joint almost linear; body scarcely constricted at the middle; elytra without transverse lines of scale-like hairs ..... 3. **Alepidia** Reut.

Division 4. Ceratocapsaria n.n.

Pronotum anterior to the middle nearly cylindrical, then rather abruptly flaring to the humeri; elytra sparsely clothed with long hairs ..... 1. **Pamilia** Uhl.

Pronotum regularly narrowing anteriorly, its sides not constricted at the middle 1

1. Elytra parallel; head vertical ..... 2. **Tiryas** Kirk

— Elytra with costa more or less arcuate; head obviously oblique ..... 3. **Ceratocapsus** Reut.

Division 5. Lopidearia n.n.

Vertex prominent, convex, its base strongly carinate across its whole width; anterior edge of pronotum not elevated.... 3. **Hadronema** Uhl.

Base of vertex carinate only at the middle, carina not reaching the eye, anterior margin of pronotum elevated 1

1. Basal two joints of antennae incrassate, the second narrowed toward its apex and sometimes flattened in males..... 1. **Lomatopleura** Reut.

— Second antennal joint linear or nearly so..... 2. **Lopidea** Uhl.

Division 6. Orthotylaria Douglas and Scott

Pronotum constricted behind callosities, constriction continued over the sides, body elongated 1

Pronotal stricture if present not continued over the sides 2

1. Posterior coxae distant; basal joint of antennae a little longer than head; pronotum with a collar-like constriction ..... 1. **Pseudoxenetus** Dist.

— Posterior coxae contiguous; basal joint of antennae short, scarcely surpassing clypeus ..... 2. **Globiceps** Fieb.

2. Eyes placed near or before the middle of sides of head 3

— Eyes placed on hind margin of head, vertex not continuing around behind the eyes 4

3. Head a little triangularly produced before the eyes; vertex and front together convex, base of the former rounded over and not at all carinate; elytra parallel; membrane biareolate.... 3. **Paraproba** Dist.

— Head truncate before, not produced before eyes; vertex broadly excavated, base arcuated and carinate; elytra broad, the embolium well developed; areoles of membrane merged into one, dividing nervure nearly or quite obsolete, their surface similar in structure to the diaphanous corium and cuneus .....4. **Hyalochloria** Reut.

4. Eyes rounded behind, in conformity with the curve of the base of the vertex, thus bringing eyes away from pronotal angles; base of vertex ecarinate in the male, very obtusely carinate in the female; elytra ample, flat, subhyaline .....5. **Diaphnidia** Uhl.

— Hind margin of vertex and eyes forming nearly or quite a straight line, thus bringing eyes into proximity to pronotal angles 5

5. Tender whitish insects with elytra a little wider than humeri; basal joint of antennae lineate with black exteriorly; vertex ecarinate. .....6. **Reuteria** Put.

— Sometimes tender and whitish, then with vertex carinate at base and first antennal joint without a black line 6

6. Vertex with a distinct carina at base behind a transverse impression, this impressed area sometimes with a foveate dot on either side.... 7

— Vertex without a distinct basal carina; sometimes tumid at base, simulating an obtuse carina, with surface before it broadly triangularly depressed 8

7. Head viewed from the side short, apex never produced the length of the eye below its lower angle; pronotum without a round black spot behind callosities .....7. **Orthotylus** Fieb.

— Head viewed from the side longer, apex produced at least the length of the eye below its lower angle; pronotum with an impressed round spot behind outer angle of callosities.....8. **Ilnacora** Reut.

8. Head vertical, with an oblique impression either side on vertex; clypeus prominent, convex, well distinguished at base; body above smooth, clothed with deciduous black hairs and minute silvery scale-like hairs (type *Macrotylus angularis* Uhl)....11. **Pseudopsallus** n. gen.

— Vertex without an oblique impression at base 9

9 Pronotum with its base elevated above base of scutellum, strongly declinate anteriorly, its vertical height about equal to that of head; basal two joints of antennae flattened; body opaque, hirsute, elytra marked with black and white .....9. **Semium** Reut.

— Pronotum not greatly raised above base of vertex and little above the level of scutellum; antennae not flattened 10

10. Hind femora normal, not saltatorial 11

— Hind femora very broad (nearly one-third its length), saltatorial; head short, vertical; vertex ecarinate; basal antennal joint short, scarcely surpassing apex of tylus .....15. **Parthenicus** Reut.

11. Head transverse, vertical, viewed from above not projecting before eyes; pronotum campanulate, humeri prominent; males with their second antenual joints clavate.....10. **Mecomma Fieb.**

— Head viewed from above angularly produced before the line of the eyes; pronotum trapezoidal, humeri not abruptly prominent; antennae never clavate 12

12. Head vertical; dimorphic, females ovate, with eyes strongly arcuated and membrane abbreviated, males with elytra parallel; green or green and black insects ..... **12. Labopidea** Uhl.
— Head oblique, produced before eyes for about length of eye 13
13. Large green ovate species, with the body narrowed before and behind, tylus moderately produced; rostrum reaching to middle of venter (type *Macrotylus vestitus* Uhl.) ..... **13. Macrotyloides** n. gen.
— Smaller and more slender species, with the body linear; tylus compressed and semicircularly prominent, occupying about half the length of head beyond apex of eyes ..... **14. Argyrocoris** Van D.

Tribe Phylini Douglas and Scott

Prosternal xyphus depressed on its disk, its margin more or less elevated; arolia rather long and flattened, usually united with the claws ..... Division 1. **Oncotylaria** Reut.
Prosternal xyphus convex, immarginate; arolia short and united with the claws or wanting ..... Division 2. **Phylaria** D. and S.

Division 1. Oncotylaria Reut.

Tarsal claws short and strongly incurved; arolia free, laminate, as long as the claws; clypeus prominent, viewed from the side strongly curved ..... **1. Macrotylus** Fieb.
Tarsal claws longer, nearly straight, or somewhat curved toward their apex 1
1. Head long, rostrate-produced, when viewed from the side projecting before the eye for about twice the length of the eye; prosternal xyphus sometimes moderately convex, but a distinct marginal carina can be seen when vestiture is removed; body broad, ovate, much narrowed before; surface clothed with a fine whitish vestiture intermixed with stiff black hairs ..... **2. Haplomachidea** Reut.
— Head not produced before the eye for more than length of the eye; body oblong or elongated, clothed with a minute or uniform vestiture 2
2. Clypeus prominent, its base but poorly distinguished from the front, placed much above the line of antennae; basal lobe of scutellum much exposed; arolia long, exceeding apex of claws, with which they are united for their whole length ..... **3. Onychumenus** Reut.
— Clypeus moderately prominent, its base well distinguished from the front and placed a little above the line of antennae; base of pronotum rectilinear, leaving basal lobe of scutellum but narrowly exposed; arolia slender, becoming free toward their apex and surpassing the middle of the claws ..... **4. Oncotylus** Fieb.

Division 2. Phylaria Douglas and Scott

Head more or less produced; when viewed from the side having facial angle (between bucculae and line of clypeus) less than a right angle 1

Head not or scarcely produced, when viewed from the side having the facial angle nearly or quite a right angle 10

1. Clypeus broad, depressed; first antennal joint not or scarcely surpassing clypeus ..... 3. **Sthenarus** Fieb.
— Clypeus prominent, convex 2
2. Femora black or pale and dotted in longitudinal series; rarely pale without dots, then with tibiae dotted and marked with a darker or black spot at base 3
— Femora pale and irregularly dotted with darker or black; often without dots, then with tibiae pale without black points 7
3. Head rostrate-produced, projecting before the eye for a distance much greater than length of eye; second antennal joint broadly flattened in the male; femora black ..... 5. **Criocoris** Fieb.
— Head not produced before the eye for a space greater than width of the eye; second antennal joint linear in both sexes 4
4. Femora black; body above conspicuously clothed with white hairs. ..... 10. **Apocremnus** Fieb.
— Femora pale, dotted in longitudinal series; rarely black, then the body above with a fine pale pubescence only 5
5. Tibiae dotted; antennae with second joint uniformly colored, or if partly colored paler at middle or apex 6
— Tibiae pale without dots, bristles only dark; femoral dots sometimes obsolete above; antennae with second joint black on apical half. ..... 7. **Rhinocapsus** Uhl.
6. General color of whole body red or reddish-brown ..... 8. **Gerhardiella** Popp.
— General color pale, whitish or tinged with yellow, marked more or less with fuscous or black areas, sometimes entirely black ..... 9. **Plagiognathus** Fieb.
7. Femora pale and irregularly dotted, at least below..... 2. **Psallus** Fieb.
— Femora pale without dots 8
8. Color uniformly black or nearly black above, legs pale 9
— Color pale, more or less marked with fuscous or black above ..... 1. **Reuteroscopus** Kirk.
9. First antennal joint surpassing clypeus by more than half its length; body polished and nude above ..... 6. **Microphylellus** Reut.
— First antennal joint scarcely surpassing apex of clypeus; body above clothed with pale pubescence ..... 4. **Leptotylus** n. gen.
10. Vertex distinctly carinate at base; rostrum short, but little surpassing the anterior coxae ..... 15. **Myochroocoris Reut.**
— Vertex without a basal carina; rostrum longer 11
11. Second antennal joint linear, neither clavate nor flattened 12
— Second antennal joint clavate or flattened and broader than first joint 21
12. Clypeus well distinguished from the front by an incised suture 13
— Clypeus confused with the front or with suture very obscure; size small (2–3 mm.) 17

13. Hind femora not at all saltatorial, not wider than the eye viewed from the side, pale, dotted in longitudinal series; tibial bristles black and inserted in black points; first joint of rostrum scarcely attaining base of head 14
— Hind femora saltatorial, much thickened or flattened, distinctly wider than lateral width of the eye 15
14. Head broad, its width three-fourths that of hind margin of pronotum; viewed from the side produced below the eye for a distance as great as length of eye ..... **12. Bolteria** Uhl.
— Head narrower, hardly more than half as broad as basal width of the pronotum; viewed from the side shorter, produced below the eye for hardly more than half length of the eye; body densely clothed with white deciduous hairs ..... **11. Oligotylus** n. gen.
15. Femora black, tarsi annulated with white; body small, black ..... **20. Strophopoda** n. gen.
— Femora pale, dotted with fuscous or black points 16
16. Base of clypeus on a line with the insertion of antennae ..... **16. Atomoscelis** Reut.
— Base of clypeus above line connecting base of antennae ..... **17. Europiella** Reut.
17. Third joint of hind tarsi as long as first and second together; arolia short, linear; attached to base of claws ..... **18. Tuponia** Reut.
— Third joint of hind tarsi subequal to second, or shorter 18
18. Head broad, about one-fifth narrower than hind margin of pronotum; body black, hind femora black ..... **19. Chlamydatus** Curt.
— Head narrower; body, including legs, pale 19
19. Head viewed from the side forming a squarish projection below the eyes; legs and antennae pale, immaculate; tibial spines black; body pale, clothed with short, thick black hair ..... **23. Maurodactylus** Reut.
— Head forming a very short angular projection below the eyes 20
20. Legs pale, femora immaculate; second antennal joint annulate with black ..... **22. Cylloceps** Uhl
— Legs pale, hind femora dotted with black; first antennal joint annulate with black ..... **21. Campylomma** Fieb.
21. Second antennal joint terete, but little thickened at apex, longer than third and fourth together ..... **24. Rhinacloa** Reut.
— Second antennal joint of the male broadly flattened 22
22. Body black, elytra pale brown, bifasciate with white ..... **14. Leucopoecila** Reut.
— Body entirely blue-black, or only coxae pale ..... **13. Atractotomus** Fieb.

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COLLEGE OF AGRICULTURE, AGRICULTURAL EXPERIMENT STATION
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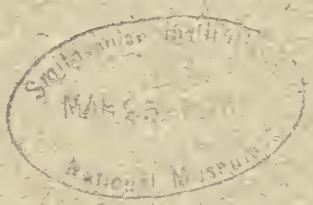

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Hyalochloria bella n. sp.

Larger than *Orthotylus compsus* Reut. from Jamaica; fulvo-testaceous, elytra white, beautifully varied with clear green blotches. Length 3.5 mm. to tip of membrane.

Head small, vertical. Vertex broad and with base of front much flattened and depressed between the prominent eyes; apex of front convex; clypeus narrow and prominent. Eyes rather large; viewed from the side ovate, reaching two-thirds of the way to gula. Antennae inserted near to and a little above inner angle of the eye; first joint not so long as head, second more than three times longer. Rostrum long, reaching well over base of venter. Elytra ample, costa expanded for the first one-fourth of its length, beyond that subparallel. Bristles of hind tibiae pale and very minute.

Color fulvo-testaceous. Pronotum in fully matured examples yellowish, with about six green blotches on posterior lobe. Scutellum sometimes varied with green. Elytra whitish hyaline, clavus, corium, cuneus and membranal areoles quite regularly blotched with irregular squarish pale green spots. In *compsus* the green is more irregularly distributed and on the membrane is confined to the small areole and the apical half of the larger one. In *bella* there is a series of green points along the costa which is wanting in *compsus*, and, as mentioned above, the size is considerably larger.

Both of these species are intermediate between *Hyalochloria* and *Diaphnidia*, but the short head and excavated vertex would seem to place them nearer to the former, although the elytra are less expanded, with the embolium much less complete.

Described from one male and four female examples taken by me at Alpine, San Diego County, California, in June and July, 1913. It is worth noting here that Mrs. Slosson has taken *Hyalochloria caviceps* Reut. at Biscayne Bay, Florida, thus bringing the typical form of the genus within our territory.

Genus **Labopidea** Uhler

Form oblong in the male, ovate with abbreviated elytra in the female. Color green, sometimes marked with black, and rather densely clothed with pale appressed hairs. Head broad, vertical, with eyes wider than anterior margin of pronotum. Vertex broad, at least three times as wide as eyes, triangularly depressed, this depression really formed by two oblique, impressed vittae, behind which the surface is lower but leaving the hind margin convex and almost carinated across the middle. Front broad and convex in both diameters. Clypeus broad and prominent, its base almost attaining the line of the eyes, sharply distinguished from the front. Antennae rather long, inserted near lower angle of eyes; first joint short, second at least three times longer, third and fourth becoming thinner. Eyes small, prominent, surpassing by nearly their whole width the pronotal angles; viewed from the side short-oval, scarcely reaching to the middle of the side of the head. Pronotum transverse, rather convex, its length about half the basal width, sides strongly oblique, straight, anterior angles well rounded; hind margin depressed, nearly covering basal lobe of scutellum. Elytra well developed in the male; short, with costa strongly arcuated in the female, in which the membrane is frequently reduced to a mere margin. Membrane when developed biareolate. Rostrum scarcely attaining the hind coxae. Arolia free and converging. Wing-cell without a hamus.

Dr. Uhler describes the eyes as almost pedunculate, but that appearance is caused by their rounded, bead-like form when viewed from above, and perhaps in part by the rounded anterior angles of the pronotum. The genus was founded upon a female very like the female of *scricatus*, but somewhat marked with black. The large thick green bodies clothed with a close hoary pubescence, the thick vertical head and the short rounded elytra

of the females will distinguish this genus from *Orthotylus* and its allies. Our species may be distinguished as follows:

Antennae black 1
Antennae pale 2
1. Legs pale, the body beneath mostly pale.....2. **simplex** Uhl.
— Legs black, the body beneath mostly black .....1. **nigripes** Reut.
2. Tibial spines slender, pale .....3. **sericata** Uhl.
— Tibial spines stouter, black .....4. **atriseta** n. sp.

1. **Labopidea nigripes** (Reut.)

A large, stout, bluish-green species with minute pale pubescence, and antennae, legs and all beneath black. Male nearly the form of *Ilnacora malina* Uhl., elytra about parallel, with apex of corium almost attaining tip of abdomen; female broad-ovate, widest at base of membrane, tip of membrane scarcely if at all surpassing abdomen. Length 5.5 mm. to tip of membrane.

Head large; vertex broad, nearly four times as wide as the small eyes, hind margin arcuate and somewhat thickened or subcarinate, transverse depression appearing foveate. Front prominent, convex, scarcely polished. Antennae rather long; first joint scarcely as long as head; third two-thirds length of second; fourth short, about one-third length of third. Pronotum short, transverse; callosities small, prominent and distant. Hairs on antennae and legs pale and inconspicuous.

Dextral hook of male genitalia ovate at base, incurved apex narrower but obtuse; sinistral hook broad, convex basally, produced distally, with an acute hook at either angle.

Color uniform bluish-green above, becoming yellowish on vertex and front of pronotum; marked with black as follows: eyes, antennae, a large round spot on front reaching to antennal sockets, tylus, legs, sternum, membrane and abdomen, or at least a broad, median vitta on tergum and venter. Callosities sometimes black.

The type was from Ormsby County, Nevada, and I took a small series at Fallen Leaf Lake, California, in July, at an altitude of 6300 feet. Dr. J. C. Bradley has sent me two females that he took at Roger's Pass in the Selkirk Mountains, British Columbia, in July, 1908. These differ from the type form in having a darker vestiture and in having a black mark covering the callosities and most of the front of the pronotum and a black dot on either side of the base of the vertex.

2. **Labopidea simplex** (Uhler)

Similar to preceding in size and form, but the elytral membrane is more developed in all the females I have seen. Like *nigripes*, it has a bluish-green color above, with pale pubescence and black antennae, but here the legs and lower surface are mostly pale. Length 5 to 5.5 mm. to tip of membrane.

Basal depression of vertex large but sometimes obscure, with hind margin quite distinctly carinate. Callosities small, prominent.

Dextral genital hook of male enlarged into a nearly circular hirsute plate; sinistral broad as in *nigripes*, but obtusely produced exteriorly and acutely hooked at its inner angle.

Color dull bluish-green, becoming yellowish on pronotum anteriorly, on head, legs, and beneath. Frontal black spot obsolete, or indicated by a broad brown arc on either side; clypeus black, at least at base. Antennae black, middle of second joint more or less distinctly brown; callosities generally with black arc bounding them behind. Basal suture of scutellum blackish. Elytra with costal border and cuneus paler, membrane quite uniformly smoky. Tarsi fuscous or black. Pale pubescence longer and denser than in *nigripes*.

The types were from Colorado. I took both sexes at Boulder in that state, July, 1903, and the Academy of Natural Sciences of Philadelphia possesses a series from Alamogordo, New Mexico, taken in April and May, 1902. As nearly as I can judge from Reuter's description, his *Hyoidea grisea* seems to be a straight synonym of this species.

3. **Labopidea sericata** Uhler

Size and form nearly of *nigripes*, male with very long elytra. Color whitish-green, with disk of pronotum and elytra strongly tinged with bluish-green; upper surface densely clothed with long white pubescence intermixed with deciduous silvery scale-like hairs. Length, female 4.5 mm.; male 7 mm., to tip of elytra.

Head proportionately longer and more pointed than in *simplex*. Base of vertex distinctly carinate in male, scarcely so in female, in which the transverse depression is much reduced. First antennal joint short, scarcely as long as dorsal aspect of the head; second about as long as hind margin of pronotum; third two-thirds length of second; fourth about half length of third. Pronotum short, in male strongly narrowed anteriorly; callosities large, oval, prominent. Elytra in male very long, apex of corium a little surpassing tip of abdomen; membrane long, whitish-hyaline, scarcely infuscated; nervures green; in female shorter

than abdomen, with membrane reduced to a mere border to apex of corium. Legs short, tibiae and some minute dots on apex of femora green.

Dextral hook of male genitalia small, nearly circular at apex; sinistral subtriangular, its inner angle produced in a short tooth, the outer prolonged in an incurved subacute horn.

Color pale bluish-green, becoming yellowish on head, pronotum before, and on lower surface. Antennae pale, scarcely darker at apex. Sides of pectus and abdomen more or less greenish, perhaps wholly green in life. Tibiae pale, with minute pale hairs and a few longer brownish bristles. Elytral costa paler; membrane whitish, with a very faint apical clouding, nervures green.

The types of this species were from Colorado, and I found it common at Denver, Boulder, Ward, and Sunset, Colorado, in July, 1903. The female has been determined for me as *Labopidea chloriza* Uhler, but it wants the black markings mentioned in Uhler's description, and for the present I prefer to consider *chloriza* as a species unknown to me.

Labopidea atriseta n. sp.

Closely allied to *sericata* Uhler, but distinguishable by having infuscated antennae, and tibiae armed with conspicuous black bristles set on black dots, while in *sericata* these bristles are weaker and fewer and are not inserted in black points. Color as in the preceding form. Length 5 mm. to tip of membrane.

Head as in *sericata*, vertex feebly carinate at base; front convex, clypeus prominent. Antennae a little longer than in allied species; second joint about three times as long as basal; third, three-fourths the length of second, the fourth short. Rostrum a little shorter than in *sericata*, scarcely attaining apex of intermediate coxae. Elytra with membrane developed in all my specimens, apex of cuneus attaining tip of abdomen.

Color a soiled whitish, more or less tinged with dull green below; disk of pronotum and scutellum and the elytra dull bluish-green, costal margin broadly pale; cuneus pale except its inner angle. Membrane obviously infuscated, with a deeper shade outwardly beyond the areoles. Antennae infuscated, basal joint pale. Hind femora distinctly dotted with greenish-brown exteriorly, tibiae armed with stout black bristles much longer than the width of the joint, each springing from a black point. Tarsi and tip of rostrum black.

Described from four females taken by me at Alpine, Mussey's, and Sweetwater Valley, San Diego County, California, in April and June.

Genus **Macrotyloides**, n. gen.

Elongate, ovate, widest near apex of clavus. Head strongly produced, subhorizontal, with eyes as wide as pronotum at transverse incisure and a little more than half its basal width, its length about equal to the median length of pronotum. Vertex sometimes flattened or impressed before the base, leaving the edge obtusely prominent, but scarcely carinate as in *Orthotylus*. Vertex and front together when viewed from above scarcely longer than wide, but slightly convex. Clypeus prominent, arcuated before, its base well distinguished from the front and on a line with the antennal sockets. Inner cheeks prominent, the outer narrow. Eyes rather small, their inner margins feebly divergent; viewed from the side oval, a little oblique, reaching over half-way to gula; gula nearly horizontal. Antennae long, inserted close to lower angle of eyes, first joint with two setae within near their apex. Rostrum long, attaining middle of venter. Pronotum trapezoidal, its anterior margin about half the posterior; sides rectilinear, obviously carinated; callosities large, little elevated. Basal lobe of scutellum exposed. Prosternal xyphus with margins carinate. Elytra rather short, with costa quite strongly arcuated. Wing-cell without a hamus. Legs rather long; tibiae with short, feeble bristles. Hind tarsi linear, joints but slightly distinguished, basal shorter than the other two, which are subequal; claws short, arolia rather large, free and connivent, not equalling the claws. Vestiture not very dense, of soft white hairs sometimes intermixed with stiffer fuscous ones.

Type of the genus *Macrotylus vestitus* Uhler.

This genus includes rather large green Capsids suggesting *Labopidea* Uhler, but with smaller eyes and a produced oblique head as in *Macrotylus;* the tylus less prominent and the claws large, with their arolia free and approaching at apex. When the elytra are closed the body is conspicuously narrowed both before and behind. Our species may be distinguished as follows:

Membrane about equally and lightly infuscated.....**vestitus** Uhl.
Membrane with the apex abruptly fuscous .....**apicalis** n. sp.

Macrotyloides vestitus (Uhler)

Long ovate, narrower before; pale grass-green, becoming yellowish when dry; membrane very faintly and uniformly enfumed. Length 5 to 6 mm.

Head nearly horizontal. Vertex hardly flattened, more than twice as wide as the eyes in the male, its basal margin appearing a little thickened in some individuals; front, feebly convex

obscurely transversely striate. Basal joint of antennae surpassing tip of clypeus by nearly half its length; second slender, about four times the length of first; third and fourth together nearly as long as second, fourth about equal to first. Rostrum reaching on the third ventral segment in the female, to the fifth in the male, first joint surpassing base of head. Pronotum nearly flat and horizontal, the surface before callosities scarcely depressed, anterior edge with a slight median sinus; sides straight, subcarinate. Scutellum equilateral. Elytra elliptical, nearly flat, cuneus scarcely longer than broad; abdomen reaching to middle of cuneus in the male, nearly to apex of membrane in the female. Membrane surpassing cuneus by about one-third its length.

Male genital pieces large; dextral hook very large and curved in conformity with the margin of anal opening, in form ligulate, its subacute tip reaching over onto apex of tergum; sinistral almost equally long and similar in form, produced either way and lying parallel with and just below the dextral, its inner end obtuse, the outer acute. Female pygofers short, beginning behind middle of venter, hind edge of fourth segment almost straight across.

Color pale green, becoming yellowish on head, pronotum, legs, antennae, and lower surface in dried specimens. Antennae infuscated toward apex. Tibial bristles fuscous; apex of tarsi black. Vestiture composed of a fine soft pubescence and short stiff fuscous hairs intermixed. Membrane nearly hyaline, nervures green.

Redescribed from five male and three female examples taken in San Diego County, California, at Alpine, Mussey's, and Foster's, from April to June.

Macrotyloides apicalis n. sp.

Closely allied to the preceding; a little shorter behind, with apex of membrane deep smoky brown. Length 5.5 to 6 mm. to tip of the membrane.

This species is very close to the preceding in most of its characters, but the elytra are shorter, making the insect appear broader; tibial bristles shorter and more slender, and the basal joint of the rostrum scarcely passes the base of the head. Oviduct of the female longer, beginning distinctly before middle of venter, with fourth ventral segment strongly oblique, not practically transverse as in *vestitus*. Color light green, becoming yellowish on head, pronotum, and below, as in *vestitus*. Antennae infuscated at apex. Membrane whitish-hyaline with its apex beyond the tip of cuneus abruptly blackish-fuscous.

Described from six females from southern California. I took it at Alpine, San Diego County, in June, and Mr. Fordyce Grinnell has sent me specimens taken at Pasadena, June, Los Angeles, September, and from the Santa Rosa Mountains.

Pseudopsallus n. gen.

Aspect of *Plagiognathus* nearly, but having cell of wing without a hamus and arolia free and connivent. Body clothed with long black hairs and short, appressed, silvery scale-like hairs or tomentum, which soon wear off, leaving the insect smooth.

Head broad and short, vertical. Vertex with an oblique impression either side, leaving the base prominent but hardly carinate. Front moderately convex, perpendicular or nearly so. Clypeus broad, somewhat prominent, but little compressed; base well distinguished from the front; apex of head blunt, produced below the eye for less than length of the eye. Eyes large, prominent, viewed from the side ovate, reaching below middle of side of head. Antennae inserted near lower angle of eye, short, stout; basal joint not longer than head viewed from above, second scarcely thinner at base than first. Pronotum transverse, smooth, anterior margin about half the length of the posterior, sides ecarinate, nearly straight, anterior angles broadly rounded. Callosities large, little elevated. Basal lobe of scutellum covered. Elytra broad, costal margin considerably arcuated in the female, nearly parallel in the male. Rostrum reaching onto base of venter; oviduct of the female long, beginning before middle of venter. Wing-cell without a hamus. Legs thick, irregularly dotted, tibial spines stout, black. Tarsal claws small but longer than in *Macrotylus;* arolia free and connivent.

Type of the genus *Macrotylus angularis* Uhler.

The type species has much the aspect of a large *Plagiognathus*, but the absence of a hamus in the wing-cell and the free connivent arolia places it in the *Orthotylini*, where there is no established genus that will receive it.

Pseudopsallus angularis (Uhler)

This species and the next are broad forms, and have little in common with the other genera of the *Orthotylini,* but they must be placed in that tribe. *Angularis* is a slaty-brown species with the claval suture, costa, the two principal nervures of the corium, and the membranal nervures whitish, sometimes tinged with yellow on the costa. The region of the callosities is black varied with white, and the head is white, with the oblique impressions

of the vertex, a large arc on either side of the front, some marks on the base and sides of the clypeus and the lorae black. The antennae are black, the second joint as long as the base of the pronotum and one-fourth longer than the third and fourth taken together. The legs are white, with the tibiae dotted with black. The white markings, especially on the head and pronotum may become more or less orange.

Dextral hook of the male genitalia apparently a flattened truncated scale scarcely longer than broad; sinistral very large, expanded on the right to base of dextral hook and exteriorly narrowed and curved upward and inward to superior aspect of anal opening.

I took three examples of this insect from the white sage growing on the mesa at East San Diego, California, during April and May, 1913.

Pseudopsallus verticalis (Uhler)

This is a smaller, pale brown or testaceous form, with the head and anterior lobe of the pronotum fuscous, the base of the vertex marked with pale, and the legs pale dotted with fuscous. The types were from California. I possess one female taken by Mr. Fordyce Grinnell at Pasadena, May 25, 1909, and another taken in Colorado was sent to me by Professor Baker labelled *Macrotylus verticalis* Uhl. MS. It probably was by an oversight that Dr. Uhler failed to mention the Colorado locality in connection with his description.

Argyrocoris femoratus n. sp.

Smaller and darker-colored than *scurrilis:* slender; testaceous-grey, more or less infuscated, cuneus dotted with red. Length 4 mm. to tip of membrane.

Head strongly oblique; vertex convex, ecarinate; front moderately convex. Eyes large oval, viewed from the side oblique and attaining gula, coarsely granulated. Antennae long; basal joint surpassing head by one-half its length; second over three times the length of first; third and fourth together about equal to second. Pronotum transverse, its length about three-fifths its basal width, anterior margin about two-thirds of posterior; hind edge depressed, covering basal lobe of scutellum. Rostrum long, reaching middle of venter. Elytra long and narrow; tip of abdomen not attaining apex of corium, cuneus slender, its length nearly three times its basal width in the male. In the female the abdomen reaches to about the middle of the cuneus, which is

broader and shorter than in the male. Hind femora long and much flattened.

Male genitalia small; dextral hook about twice longer than its basal width and tapering to a point; sinistral oval and lying along the sinistral notch.

Color greyish-testaceous; callosities narrowly black; disk of pronotum with two broad fuscous rays more or less distinct. Scutellum infuscated or almost black. Elytra dotted with sanguinous on cuneus and sometimes more sparsely on corium and clavus. Membrane deeply infuscated, nervures pale dotted with red. Wings somewhat infuscated, with blackish nervures. Body beneath infuscated. Antennae and legs pale, femora dusky, hind pair more or less dotted with red points; tarsi black at apex. Antennae slightly infuscated toward their apex. Upper surface clothed with minute silvery pubescence, obscurely arranged in lines which are more distinct on the head, where they form three longitudinal vittae.

Described from numerous examples beaten from chaparral in San Diego County, California, at Coronado, National City, Alpine, etc., in May and June.

At first sight this species seems very different from *scurrilis*, but a closer inspection shows that it possesses similar generic characters and there can be no doubt that it should be placed in the same genus.

Parthenicus picicollis n. sp.

Allied to *psalliodes*, but with pronotum, scutellum and commissure piceous or almost black; beneath more or less infuscated, above pale, more or less closely dotted with sanguinous points, elytra appearing dark red; membrane black. Length 3 mm. to tip of membrane.

Head vertical; vertex and front conjointly flattened above, a very little convex below, base of vertex carinate. Clypeus prominent, but somewhat less so than in *Macrotylus*, its base well distinguished and distinctly above line of antennae. Eyes large, prominent, projecting for nearly their whole width beyond the pronotal angles; viewed from the side broad-oval, vertical, reaching almost to gula, face but little prominent before the eyes, almost half of this being projection of clypeus. Antennae rather short, first joint but little surpassing clypeus; second longer than basal margin of pronotum. Pronotum moderately convex, callosities small and little elevated, distinguished behind by a deeply incised line. Basal lobe of scutellum covered. Costal margin of elytra feebly arcuated. Cuneus about as long as wide at base in

the female, longer in the male. Hind femora about one-third as wide as long in the female, hardly one-fourth in the male.

Dextral hook of the male genitalia slender toward its apex, bent at a right angle dorsally; sinistral somewhat crescentic, its inner (dextral) angle produced.

Ground color pale yellowish-testaceous. Head, legs, and elytra dotted with dark sanguinous, the latter closely, almost confluently so, appearing as if washed with red. Antennae pale, basal joint red, apex slightly infuscated. Pronotum and scutellum deep piceous or almost black; elytral commissure evenly and indefinitely clouded with fuscous, this clouding scarcely extending onto inner angle of corium. Membrane blackish, with a pale line around apex of cuneus, nervures red. Face sometimes dusky, clypeus and cheeks clear red. Lower surface and base of hind femora more or less infuscated; tibial bristles fuscous, springing from sanguinous dots. Upper surface clothed with a fine pale pubescence.

Described from fifteen examples beaten from *Adenostoma* in San Diego County, California, from July to October. Although closely allied to *psalliodes*, this form seems sufficiently distinct by its dark pronotum, scutellum and lower surface, and the concolorous inner angle of the corium

Transmitted January 3, 1916.

UNIVERSITY OF CALIFORNIA PUBLICATIONS
TECHNICAL BULLETINS
COLLEGE OF AGRICULTURE, AGRICULTURAL EXPERIMENT STATION
ENTOMOLOGY
Vol. 1, No. 5, pp. 229-249 May 23, 1916

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BY
EDWARD P. VAN DUZEE

UNIVERSITY OF CALIFORNIA PRESS
BERKELEY

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In the summer of 1915 it was my privilege to spend about five weeks in the Sierra Nevada with the entomological field class of the University of California Summer School at Fallen Leaf Lake, Eldorado County, California. We reached Fallen Leaf Lodge, our headquarters, on June 21 and left on July 31, a period which covered the season of greatest abundance of insects in certain of the orders, notably the Hymenoptera, Diptera and Lepidoptera, and the Coleoptera were perhaps at their best before we left; the Hemiptera and Orthoptera were, however, just coming into season, so the material obtained in these orders was but fragmentary. Circumstances were such that I was able to devote much of my time to the collection of insects for the University Museum, and Professor Woodworth added a number of interesting forms during two brief visits to the Lodge, while other members of the party turned over to me some good things taken by them. Altogether over six thousand mounted insects were brought home, a study of which will undoubtedly make valuable additions to our knowledge of the Sierran insect fauna.

The present paper deals with the Hemiptera taken, but, owing to the earliness of the season, must be but an imperfect representation of the hemipterous fauna of that portion of the Sierra. Of the one hundred and forty species enumerated, perhaps one-third are known to inhabit the coast region of California and about one-fourth are common to the eastern and

northern portions of the United States and Canada. A number of forms characteristic of the Rocky Mountain region were taken, as well as several found in the hilly back-country of San Diego County, California. However, before any really useful studies on the distribution of the Hemiptera of this portion of the Sierra Nevada can be made, it will be necessary to do systematic collecting there during August and early September. It is interesting to note that twenty-one of the species taken, or approximately one-seventh, are new to science, which shows how little is now known of the Hemiptera of the Lake Tahoe region.

The following notes on localities will indicate the conditions under which most of the material was taken.

Lower end of Fallen Leaf Lake.—On the west side of the lake from Cathedral Park and the sawmill to the outlet and some distance north was an interesting locality with low, rich woods and open, marshy fields. Mosquitoes were a serious hindrance here but the Hemiptera were more numerous than elsewhere, perhaps because the season was earlier at this altitude, 6300 feet.

Lateral Moraine.—A sharp ridge along the eastern side of the upper end of Fallen Leaf Lake, with an elevation of about 800 feet above the lake. This ridge was well covered with chaparral and until about the tenth of July made an excellent collecting ground for the Hymenoptera, Diptera and Lepidoptera. After that date it became too dry for good collecting.

Angora Lakes.—Situated under the eastern escarpment of the Angora Ridge at an altitude of about 7500 feet. Collecting here was poor.

Glen Alpine Springs and Creek are situated in a valley running west from the upper end of Fallen Leaf Lake. Below Glen Alpine Springs the valley is well wooded and afforded excellent collecting places. Toward the last of July the northern side of the valley formed by the southern slope of Mount Tallac proved to be one of our best collecting grounds.

Cathedral Lake, in a valley on the eastern slope of Mount Tallac at an altitude of about 7500 feet, was a moderately productive place, especially lower down near Floating Island Lake.

Mount Tallac.—The sloping alpine meadow on the western aspect of the mountain was a wonderfully interesting place from about the twentieth of July. The altitude here varied from about 8000 to over 9000 feet.

Angora Ridge.—The western slope of this ridge was an alpine meadow of equal altitude and hardly less interesting than that on Mount Tallac.

Half Moon Lake under Dick's Peak at an altitude of about 8000 feet proved to be an interesting place in late July. Several eastern forms not found elsewhere were taken here.

Grass Lake in the valley above Glen Alpine Springs at an altitude of about 7500 feet did not yield much of interest, but might have been better if visited later in the season.

Heteroptera

Thyreocoris anthracinus Uhler. July. Taken in numbers from a low plant growing in grassy places along the roadside from Tallac to the sawmill at the lower end of Fallen Leaf Lake.

Homoemus bijugis Uhler. Taken with the preceding.

Eurygaster alternatus Say. Abundant with the foregoing species.

Trichopepla atricornis Stål. Found occasionally on rank weeds about the lower end of Fallen Leaf Lake, July 17.

Thyanta custator Fabr. Not uncommon on trees and bushes everywhere below 8000 feet.

Banasa sordida Uhler. A single specimen swept from weeds at Half Moon Lake in July.

Tollius curtulus Stål. Low ground near Tallac, July.

Alydus pluto Uhler. One example taken on weeds growing on a dry sandy spot near Tallac in July.

Harmostes reflexulus Say. Not uncommon with the preceding.

Corizus scutatus Stål. Common on the low lands between Tallac and Fallen Leaf Lake in July.

Corizus indentatus Hambl. Taken with the preceding.

Corizus hyalinus Fabr. Generally distributed, but not common, up to 8500 feet.

Corizus crassicornis Linn. Half Moon Lake, July 23.

Aradus debilis Uhler. This, our largest western aradid, is paler than most of our species, has the abdomen of the female much produced and attenuated at apex and the third antennal joint white with its extreme base and the large apical joint black. Mr. Ralph Hopping took a series on fungi under the bark of a dead pine tree near the margin of Fallen Leaf Lake, July 2, Dr.

Van Dyke found one in a similar situation, and I took a male near Glen Alpine Springs, June 30.

Aradus hubbardi Heid. A fine series of this species was taken from fungus growing on a fallen pine tree along the trail to Angora Lakes at an altitude of about 7000 feet, July 11. In all the specimens taken the tip of the second antennal joint is scarcely paler.

Aradus persimilis, new species

Very close to *hubbardi*, differing principally in having the scutellum much broader at apex, the expanded portion of the costa longer and the antennae a little thinner, with their second segment perhaps a little longer and the third without a pale apex. Length, male 6.5 mm., female 7.5 mm.

Head as in *hubbardi;* anterior process thick, cylindrical, compressed toward the apex, reaching nearly to basal third of second antennal joint. Spine at base of antennae almost attaining the tip of first joint and armed exteriorly with a very short tooth. Occiput with a tubercle before the eye and another near its hind angle. Antennae about as in *hubbardi,* perhaps a shade thinner; first segment about one-half longer than wide, second about as long as the head, a little thickened at apex; third hardly one-half the length of second; fourth still shorter, narrowed to its base with a short conical tip. Pronotum about as in *hubbardi,* slightly longer and more broadly expanded about the humeri; sides irregularly dentate; four discal carinae nearly parallel, exterior percurrent, not becoming obsolete before as in the allied species. Abdomen as in *hubbardi;* genital segment of the female a little shorter and less expanded; genital lobes of the male shorter and more transverse. Rostrum nearly attaining hind margin of mesosternum.

Color fuscous-brown, becoming more ferruginous on the cephalic process, basal joints of antennae, pronotal carinae, principal elytral nervures, extreme tip of scutellum, and in places on abdomen. Antennae becoming black on apical two segments, conical tip of fourth sericeous pubescent. Expanded basal portion of costa and broad humeral areas and marginal serrations whitish-testaceous; elytral reticulations sometimes of the same pale color. Legs and beneath usually paler. Abdomen becoming more castaneous toward its margin, where it is often minutely pointed with green, the hind edge of the connexival segments pale; membranal veins distinctly pale.

Described from three male and two female specimens taken near Glen Alpine Creek, June 25 to July 3. While very near *hubbardi* this form seems to have good specific characters and is at least a valid subspecies. I possess one female, taken by Dr. J. C. Bradley in the Santa Cruz Mountains, California, in May, 1907, that differs from the types only in having the humeral expansion of the pronotum concolorous.

Aradus borealis Heid. Professor Woodworth took one example of this species on the eastern slope of Mount Tallac along the trail from Cathedral Lake to Floating Island Lake, on July 6, at an altitude of 7000 feet.

Aradus behrensi Bergr. A few examples were taken from trees near the upper end of Fallen Leaf Lake, June 25. The next day I took near the lower end of the lake two specimens of what I believed to be brachypterous or imperfectly developed specimens of the same species. In these the elytra reach only to the base of the fifth abdominal segment.

Aradus insolitus, new species

A small, black species marked with pale granules; humeral angles subacute, latero-anterior margins a little concavely arcuated, second antennal joint narrowly white at apex. Length 4 mm.

Form narrow ovate, about as in *tuberculifer* Kirby. Head with a short oblique impressed area on either side interior to the eye. Antenniferous tubercles with a large acute spine which surpasses the middle of first antennal segment. Antennae regularly but moderately thickened to apex of third joint; basal scarcely longer than broad, second about as long as the distance between the eyes, uniformly thickened toward its apex, white apical portion about as long as the thickness of the joint at base; third and fourth about equal in length, the latter fusiform. Pronotum rather small; humeri prominent, subacute, the margins behind them feebly rounded, the latero-anterior margin a little concavely arcuated with the anterior angles prominent and subacute; entire lateral margins quite regularly and minutely crenulate; disk a little depressed across the middle, marked posteriorly with four parallel carinae which become confused anteriorly. Scutellum narrow, about as long as pronotum, obtuse at apex, margins but little elevated. Elytra reaching nearly to tip of abdomen, but little narrowed apically; costa regularly but moderately dilated at base. Nervures of corium and membrane prominent. Rostrum reaching but little beyond the base of the head, encroaching upon base of the prosternum about the width of the sternal sulcus at its middle; this sulcus expanded at base and apex. Genital lobes of the male about as in *similis*, the oblique apical margins a little more rounded.

Color almost black; narrow apex of second antennal segment, tips of the humeri, broad but indefinite apex of scutellum, knees, tips of the tibiae and apical angles of the abdominal segments pale or whitish. Whole surface irregularly dotted with minute greenish-white granules, most numerous on the head, disk of scutellum and elevated areas of pronotum and elytra; granulations of connexivum becoming a clear sea-green in places.

Described from two males taken about the upper end of Fallen Leaf Lake, July 12. This species is very distinct from any other known to me by its subacute humeral angles and the concave latero-anterior margins of the pronotum. The short rostrum allies it with *Quilnus* and in some respects it is intermediate between that subgenus and the more typical aradids.

Aradus falleni Stål. One specimen taken from a fallen pine tree near Cathedral Lake on the eastern slopes of Mount Tallac, July 5.

Mezira moesta Stål. A single individual of this common form was taken near the upper end of Fallen Leaf Lake on July 2.

Lygaeus reclivatus Say. Found in numbers on a patch of milkweed near the sawmill at the lower end of Fallen Leaf Lake, July 25.

Lygaeus truculentus Stål. A few taken on flowers near the lower end of Fallen Leaf Lake in July.

Lygaeus bicrucis Say. Taken at Grass Lake and near Fallen Leaf Lake in late June and early July.

Nysius californicus Stål. Common at lower levels but also found at Half Moon Lake and up to 8500 feet on Mount Tallac.

Nysius cricae Schill. Half Moon Lake, July 23.

Nysius cricae minutus Uhler. A few taken near Tallac in July.

Ischnorrhynchus resedae Panz. One specimen was beaten from chaparral along the trail on the west shore of Fallen Leaf Lake, July 5.

Geocoris pallens decoratus Uhler. One example taken on the low lands near Tallac on July 25.

Ligyrocoris diffusus Uhler. With the preceding.

Sphragisticus nebulosus Fall. Swept from grass near the lower end of Fallen Leaf Lake, July 17.

Rhyparochromus angustatus Van D. This form may be roughly distinguished from *sodalicus* Uhl. by its having the third antennal joint entirely black, the lateral edges of the pronotum concolorous and the clavus ferruginous at base. It is a long narrow form and northern in its distribution. Here it was found near Tallac in July.

Scolopostethus thomsoni Reut. Three examples were taken at Tallac and about the upper end of Fallen Leaf Lake in July.

Ploiariodes sp. One example taken at the Lodge in July.

Nabis ferus Linn. Found everywhere. Here the species has every appearance of being a native insect and possibly it is indigenous to all the northern portions of this continent.

Anthocoris bakeri Popp. Taken near the Lodge, June 21. Poppius' paper describing this species never reached me and I was unaware of its existence until after the publication of my species *ornatus,* which is undoubtedly identical with *bakeri.*

Anthocoris antevolens White. Taken on the low lands about Fallen Leaf Lake in July.

Anthocoris melanocerus Reut. Two examples were beaten from the chaparral along the western shore of Fallen Leaf Lake, July 5.

Saldula interstitialis Say. One taken at Tallac July 25.

Saldula sp. Taken on the low lands about the lake and up to 8500 feet on the western slope of Mount Tallac.

Gerris orba Stål. Found on Fallen Leaf Lake, Cathedral Lake, Angora Lakes and elsewhere, in July.

Gerris gillettei L. & S. One example taken at the sawmill at the lower end of Fallen Leaf Lake, July 25.

Stenodema vicina Prov. Taken on grassy openings along Glen Alpine Creek, at Half Moon Lake, and on the western slopes of Angora Peaks, in July. No males were found but the females were not uncommon.

Platytylellus intercidenda Dist. Occasional on rank vegetation about the lower levels after July 16.

Phytocoris eximius Reut. Glen Alpine Springs, July 30. This species and the next were only just reaching maturity when I left, the last of July.

Phytocoris inops Uhler. With the preceding. This is a smaller species having the membrane varied with whitish and fuscous in coarser blotches, the antennae longer and more slender, with the basal joint more obviously banded and the pale incisures broader.

Ectopiocerus anthracinus Uhler. Occasional in July at the lower levels.

Poeciloscytus uhleri Van D. Taken at the level of Fallen Leaf Lake and up to 8500 on the west slope of Angora Peak, toward the last of July.

Poeciloscytus venaticus Uhler. Not uncommon on rank weeds about the lower end of Fallen Leaf Lake in July.

Dichrooscytus speciosus, new species

Allied to *suspectus* but more polished. Black; disk of head, pronotum and elytra deep rich wine-red; scutellum, base of cuneus and legs white; antennae soiled white. Length nearly 6 mm.

Head broader and shorter than in *suspectus,* vertex strongly impressed before the basal margin and more broadly on either side; middle of vertex quite strongly swollen and polished, without the transverse striae seen in the allied species; basal carinae prominent across the whole width. Pronotum narrower anteriorly, meeting the vertex near the inner angle of the eye; surface more strongly punctured, callosities smaller and highly polished; median line obscure but evident. Scutellum prominent, narrower than in *suspectus,* polished, a little transversely shagreened toward the base. Elytra polished, very obscurely punctured and shagreened, almost parallel, costa straight basally.

Color black, highly polished; base of vertex obscurely reddish. Pronotum deep wine-red with anterior and posterior margins black. Scutellum ivory-white, becoming black on anterior lobe beneath base of pronotum. Elytra dark wine-red; broad margins of clavus about scutellum and the apex of corium black; cuneus black, the basal half ivory-white omitting the slender costal margin. Membrane deep fuscous, iridescent, the nervures concolorous. Legs including coxae white, coxae and trochanters sometimes tinged with greenish; apex of the tibiae and the tarsi slightly infuscated, last tarsal joint becoming black at apex. Antennae soiled white, a little more infuscated toward the apex. Tergum and apex of abdomen more or less sanguinous.

Described from numerous examples beaten from juniper trees during July, mostly on the south slope of Mount Tallac. The first mature examples were taken near the Lodge on July 5 but the adults did not become abundant until after the middle of the month. This is one of the most beautifully colored capsids known to me. The immature have paler colors but the pattern is distinct and characteristic.

Dichrooscytus suspectus Reut. Common on juniper trees during July. These individuals are more uniformly colored with rufous than those from Colorado determined for me by Dr. Reuter, but they can hardly be distinct.

Dichrooscytus irroratus Van D. Common on juniper and cedar trees everywhere between 6000 and 8000 feet. In most of these examples the elytra are of an almost uniform pinkish color with a deeper tint on the cuneus, and marked with a fuscous vitta on the apex of the corium; an oblique vitta on their middle and the apex of the membranal areoles are also fuscous.

Dichrooscytus elegans Uhler. Taken with the preceding forms but less abundantly and a little earlier.

Lygidea rebucula obscura Reut. Three examples were taken about the Lodge July 20 and 21. These differ in no respect from specimens taken in the state of New York.

Platylygus luridus Reut. Not uncommon on Jeffrey pines from July 8. These are larger than eastern specimens but do not otherwise differ.

Lygus pratensis Linn. The pale form with yellowish scutellum which is characteristic of the Californian fauna was common at all the lower levels and up to 8000 feet. Three examples of the dark eastern form were taken on July 23 at Half Moon Lake.

Lygus plagiatus Uhler. This form was common above 7500 feet but rarely was taken at lower levels.

Lygus campestris Linn. Common about Fallen Leaf Lake and up to 7800 feet at Half Moon Lake.

Xenoborus canadensis Van D.? One example which may represent a distinct species differs in being smaller and in having the basal joint of the antennae and the tylus concolorous.

Camptobrochis validus Reut. Four examples were taken about Fallen Leaf Lake and Grass Lake from June 23 to July 5.

Camptobrochis fulvescens Reut. Beaten from pine on the south slope of Mount Tallac on July 30. These specimens are glabrous and have much the aspect of *nitens* but the male genital characters are those of *fulvescens* and I prefer to so place them for the present.

Deraeocoris ingens, new species

Large, deep black, polished; second antennal joint greatly thickened. Length 8 mm.

Aspect of *Capsus ater,* but much larger and more elongated, with antennae more clavate. Head as in *Camptobrochis,* prominent; hind margin of vertex and eyes nearly rectilinear. Vertex almost flat, basal margin subcarinate behind a shallow depression. Antennae stout, inserted before the eyes at a distance about equal to the thickness of first segment; this segment as long as the median width of vertex; second (3.5 mm.) longer than basal width of pronotum, at base more slender than first but regularly thickened to near its apex, where it is as thick as the antero-posterior diameter of the eye, its surface closely pubescent and armed with a few longer hairs; third and fourth segments short and slender but not setaceous, together equal to length of the anterior tarsi, third scarcely longer than fourth. Pronotum shaped much as in *Camptobrochis*

nigrita, much narrowed anteriorly, where it is a little wider than the base of the vertex; surface convex in both diameters, strongly punctured; callosities large, highly polished, impunctate, scarcely elevated and poorly defined; sides nearly straight or slightly concave. Scutellum more finely punctured. Elytra coarsely punctured, long, narrowed from the middle. Membrane long and narrow, nervure dividing the areoles obsolete or nearly so. Prosternal xyphus depressed with a carinate margin. Basal joint of hind tarsi stouter, as long as second and third together. Arolia as in *Camptobrochis*, wanting or very minute and connate with the claws, between which are two slender parallel setae. Male uncus formed about as in *Camptobrochis nitens* with a sharp curved hook at distal end which almost attains the line of the proximal extremity.

Color a uniform deep coal-black, brilliant; membrane a dead blackish-fuscous, scarcely lighter next the point of the cuneus; base of vertex and knees touched with fulvous. Second antennal joint nearly to its apex and the tarsi piceous, verging toward castaneous. Osteolar margin white.

Described from nine examples representing both sexes, all beaten from Jeffrey pines along the south slope of Mount Tallac above Glen Alpine Creek during late July. This is one of our largest capsids, and it seems strange that it should have remained unknown for so long unless it be restricted to the Jeffrey pine, which has a range in the Sierras and northwardly where little work on Hemiptera has been done. Dr. Poppius has recently sunk *Camptobrochis* as a synonym of *Deracocoris*, but I think it better to restrict the latter genus to those species having a clavate second antennal joint.

Deraeocoris fraternus, new species

This form seems to differ from *ingens* principally in being smaller (6 mm.) and in having the basal one-half of the second antennal joint and the legs pale or even bright rufus, with the apex of the tibiae darker and the tarsi black. Generally there is a pale annulus beyond the middle of the tibiae and the margins of the pleural pieces are whitish, usually broadly so.

Described from ten examples representing both sexes taken with the preceding. I would consider this but a color variety of *ingens* were it not for its much smaller size and the constancy of its characters.

Largidea grossa, new species

Form nearly that of *marginata*, but larger; dull rufus-brown, whole upper surface closely and coarsely punctured. Length to tip of membrane 6 mm.

Head impunctate, polished, clothed with sparse, short appressed pale pubescence; viewed from above short, transverse, gently swollen before; width about twice its greatest length; when viewed from before five-angled, portion above the antennae almost quadrangular with sides straight and parallel, apex obtuse; base of clypeus but feebly distinguished from the front. Rostrum attaining the base of the intermediate coxae. Antennae as in *marginata*, inserted near lower angle of eye; basal joint scarcely longer than the eye; second joint is as long as vertex and pronotum taken together, flattened horizontally and broadly lanceolate, its width equal to length of first joint, its lower surface feebly convex, the upper deeply sulcate nearly to the apex; third and fourth thin, fusiform, each subequal to the first in length. Pronotum broader and less narrowed anteriorly than in *marginata*, sides straight, distinctly carinate, attaining the middle of the eyes; posterior lobe deeply closely punctured; anterior lobe nearly smooth, gray-pubescent, transverse impressed line deep, black, bent back in a barb at either side of the median line. Scutellum strongly convex, closely but not deeply punctured. Elytra closely punctured, the costa bent beyond the middle. Cuneus long, but moderately depressed. Membrane long, surpassing the abdomen by one-half its length. Basal joint of the tarsi broad and flattened, scooped out below, wider than the apex of the tibiae and as long as slender third joint; second short, slender like third, deeply inserted in upper surface of broad first joint. Oviduct beginning before middle of venter.

Color dull rufus-brown inclining to wine-red but not as deep a red as in the allied *marginata*. Whole surface closely but not conspicuously pale-pubescent; disk of head and much of lower surface blackish; costa paler; membrane black, nervures black at base, paler beyond. Antennae reddish. Tarsi and venter blackish.

Described from a single female example taken on Jeffrey pine on the south slope of Mount Tallac near Glen Alpine Springs, July 30, at an altitude of about 7000 feet. It is possible that the expanded basal joint of the tarsi and the fact that the second antennal joint is scooped out above instead of below would entitle this form to generic distinction, but it does not seem advisable to separate it until the male has been examined. In the type specimen the thickened apex of the second antennal joint is somewhat bent, making the antennae appear to be five-jointed when viewed from the side.

Dacerla inflata Uhler. This singular looking ant-mimic was quite abundant after the middle of July at most all locations but especially along the southern slope of Mount Tallac. A few were seen above 8000 feet on Angora Ridge. It was most abundant on the lodge-pole pine, but it occurred on other trees and

a few were swept from weeds near the lake. The males scarcely differ from the females and in both sexes some individuals are paler or reddish. The pronotum and parts of the elytra that are gray in the black form are ferruginous in the pale, but most of the material taken answers in every respect to the excellent description given by Dr. Uhler.

Coquillettia insignis Uhler. Three males of this pretty species were swept from weeds near the sawmill on Fallen Leaf Lake, July 25, and one was taken next day from the western slope of Angora Peak above 8000 feet.

Dicyphus californicus Stål. A few were taken about Fallen Leaf Lake late in July.

Dicyphus agilis Uhler. With the preceding but more abundant. I distinguish this from *californicus* by its larger size, paler colors, the almost entire want of red on the elytra, the more tumid and exposed base of the scutellum and especially by the shorter basal joint of the antennae.

Dicyphus vestitus Uhler. One example was taken July 17 near the lower end of Fallen Leaf Lake.

Dicyphus crudus, new species

Form and size of *agilis;* pale greenish-white. Length 5 mm., width across the elytra little more than 1 mm.

Vertex less swollen than in *agilis,* eyes a little more prominent, with antennae longer and pronotal collar more elongated. Elytra very long, parallel, membrane surpassing abdomen by two-thirds its length.

Color pale greenish-white, deeper green on anterior lobe of pronotum, pleural pieces and base of scutellum. Eyes and tips of the tarsi black. Neck with a fuscous cloud behind each eye. Elytra almost pellucid, sparsely clothed with short apressed white hairs. Membrane with a faint longitudinal dusky cloud behind the areoles. Arolia long, lying near the small claws. Apical joint of the antennae, oviduct and genital segment of the male slightly embrowned.

Described from one pair taken on the flats near the lower end of Fallen Leaf Lake. This insect might be taken for the immature form of *agilis* were it not for the longer elytra, broader collar and flattened vertex. The fuscous cloud behind the eyes is also distinctive.

Labops hesperius Uhler. One example was taken July 31 on the shore of Lake Tahoe near the Hotel Tallac.

Lopidea nigridea Uhler. Several specimens of what I take to be a smaller form of this species were taken about Fallen Leaf Lake during July. This small form is but 4 mm. to the tip of the abdomen, the surface is more slaty-black with the stiff hairy vestiture more pronounced, and the markings are paler, being but rarely tinted with red. The male genital characters are nearly identical and it does not seem best to try to distinguish them at present.

Hadronema militaris Uhler. One example was taken on the shore of Half Moon Lake, July 23.

Hadronema robusta Uhler. A single specimen was taken with the preceding.

Paraproba hamata Van D. Upper end of Fallen Leaf Lake, June 21. A single specimen.

Orthotylus tibialis Van D. A good series of this very distinct species was taken in July from a low hirsute weed growing along the road between the sawmill on Fallen Feaf Lake and the Hotel Tallac. The descriptions of this and other new species in this genus will appear about simultaneously in the *Proceedings* of the California Academy of Science.

Orthotylus insignis Van D. A very pretty species, of which three examples were taken July 24 on the "short trail" to Glen Alpine Springs, where a tiny streamlet caused a rank growth of vegetation.

Orthotylus viridicatus Uhl. Not uncommon on the rank weeds growing near the lower end of Fallen Leaf Lake, at Half Moon Lake and near Glen Alpine Springs. The black membrane with conspicuous white veins will distinguish this pretty species.

Orthotylus uniformis Van D. A plain green species of which numbers were taken near Fallen Leaf Lake in July, mostly on the chaparral.

Orthotylus ovatus Van D. Common on junipers on the south slope of Mount Tallac late in July.

Orthotylus formosus Van D. Two examples of this very distinct form were beaten from alder bushes in a damp spot on the south slope of Mount Tallac about 200 feet above Glen Alpine Creek on July 30. I was unable to find any on the lower levels along the creek, but it is possible that the warmer location on the sunny hillside brought them out earlier than in the shaded valley.

Orthotylus affinis Van D. Abundant everywhere on willows

at the lower levels, but I also took them near Half Moon Lake at an altitude of about 8000 feet.

Orthotylus cuneatus Van D. Several specimens of this form were taken on willows about Fallen Leaf Lake in company of the preceding.

Labopidea nigripes Reut. A small series of this very distinct species were taken near the lower end of Fallen Leaf Lake in July.

Macrotylus multipunctatus Van D. The unique type of this interesting insect was taken by me near the lower end of Fallen Leaf Lake July 17. Its pale surface, closely dotted with round black points, will at once distinguish it from all the allied forms.

Macrotylus lineolatus Uhler. A few examples of this form were beaten from bushes about the lower end of Fallen Leaf Lake late in July.

Macrotylus infuscatus Van D. Taken with the preceding but in greater abundance. Unfortunately I neglected to note the food-plant of these species, but it may have been the willow which grew in several localities about there.

Microphylellus alpinus, new species

Aspect of *Microphylellus rubricans* Prov. but larger and darker; piceous black with castaneous legs. Length 4.5 mm. to tip of membrane.

Head nearly as in *modestus*, a little shorter when viewed from the side; projecting below the eye for scarcely more than the width of the eye. Vertex without a basal carina. First joint of antennae a little shorter than in the type species, surpassing the clypeus by about half its length; second joint linear, distinctly incrassate, as thick as basal joint; third and fourth together about as long as second, setaceous. Pronotum proportionately shorter than in *modestus;* humeral angles slightly prominent, sides feebly sinuated and anterior angles well rounded; callosities large, distinct, the impressed line strongly arched either side; the disk minutely transversely wrinkled, sides subacute but hardly carinate. Rostrum attaining apex of hind coxae, basal joint surpassing base of the head.

Color piceous-black, deeper on the head, pronotum and scutellum; antennae uniformly concolorous; rostrum a little paler. Legs castaneous, becoming piceous on the coxae, on the base of the femora, at least the posterior, and on the tarsi.

Described from one male example taken on the alpine meadows on the western slope of Angora Ridge at an altitude of 8500 feet, on July 26. This species is not typical of genus *Microphylellus*.

differing in the shorter pronotum, more prominent callosities, larger basal joint of the rostrum and the stouter second segment of the antennae.

Microphylellus bicinctus Van D. Taken on the chaparral along the western shore of Fallen Leaf Lake early in July. Apparently rare.

Gerhardiella delicata Uhler. Two examples were beaten from the chinquapin oaks along the western shore of Fallen Leaf Lake late in July. There seem to be no good structural characters by which to distinguish between this genus and certain related genera such as *Psallus*, *Apocremnus* and *Plagiognathus*. By separating out the forms having the femora dotted in longitudinal series and the tibiae dotted with black we have a fairly homogeneous group including the types of the genera *Plagiognathus* and *Gerhardiella*, and I can see no harm in using the latter name for the red forms, as they have quite a different aspect from the more typical forms of *Plagiognathus*. If we do this, it would seem advisable to divide genus *Psallus*, placing those forms with ovate blackish bodies and dotted tibiae in genus *Apocremnus*. It is possible that further study may disclose good structural characters for distinguishing these genera, but I have not yet detected any that seem at all constant.

Apocremnus politus Uhler. Taken about the upper end of Fallen Leaf Lake and at Half Moon Lake in July. This species is smaller and more slender than the more typical *anchorifer* Fieb., but for the present I prefer to place it here rather than in *Plagiognathus*, as it has the black femora and the white scale-like vestiture of *Apocremnus*. In this species the second antennal joint is entirely black.

Apocremnus nigerrimus, new species

Larger than *politus*, deep black, polished, clothed with coarse deciduous white hairs; apical joint of antennae concolorous, tibiae obscurely dotted. Length 3.5 mm. to tip of membrane.

Head about as in *anchorifer*, viewed from the side shorter, with the facial angle more acute; projecting below the eye for a distance equal to the greatest width of the eye. Vertex ecarinate, a little flattened. Antennae hardly shorter than in *anchorifer;* first joint surpassing clypeus by about one-third its length; second as long as pronotum and one-half the head; third and fourth together as long as second. Pronotum rather

long; its length a little more than half its basal width; the sides straight, with the anterior angles scarcely rounded. Rostrum attaining the posterior coxae, first joint reaching base of the head. Oviduct of the female long.

Color deep black, polished above, clothed with conspicuous white hairs; base of vertex with a fulvous sinuate line which (as in *politus*) simulates a carina; third and fourth antennal joints obscure castaneous, their bases narrowly blackish. Tibiae above obscure whitish, bristles and dots at their base black. Membrane almost as deeply colored as the corium, marked with a small pale spot next the tip of the cuneus, invading more or less the apex of the nervures. Osteolar orifice soiled white.

Described from twelve examples representing both sexes. Eight of these were taken by Mr. Fordyce Grinnell at Pasadena, California, June 5, 1909, and four I took about the upper end of Fallen Leaf Lake in July.

Bolteria picta hirta new subspecies

Smaller and darker-colored than *picta*, clothed with stiff black hairs; dull yellowish-green, most of the head, two transverse bands on the pronotum, scutellum in part, inner margins of the clavus, a broad distal vitta on the corium, an oval spot on the cuneus and most of the lower surface black; femora dull fulvous, marked with large fuscous dots in longitudinal series. Length 4 mm.

Head shorter and less prominent than in *picta*. Vertex a little depressed before the base, which is thickened but hardly carinate. Front convex, polished. Antennae shorter than in *picta;* first segment but little surpassing the clypeus; third and fourth together subequal to second. Pronotum, scutellum and elytra as in *picta*, impunctate, polished, clothed with stiff black hairs which are somewhat longer and more dense on the head. Rostrum attaining the intermediate coxae.

Color a soiled greenish-yellow. Head polished black; a point next the inner angle of the eye and base of the vertex fulvous, median line of the front sometimes pale. Antennae and rostrum black, extreme apex of first antennal joint pale. Pronotum marked with a broad transverse band on the callosities and a narrower one on the hind margin, black. Incised line on scutellum black. Narrow scutellar and commissural margin of clavus, a broad longitudinal vitta on corium, a short mark within the costa placed near the apex and a large oval spot covering the disk of the cuneus, black. Membrane infuscated, a cloud in the apical areole and a curved ray beyond deeper black. Beneath black, polished, osteolar region and the lower margin of propleura whitish. Legs obscure fulvous, femora infuscated at base and apex and dotted with blackish in longitudinal series; tibial bristles black springing from small black points.

Described from eight female examples beaten from sagebrush (*Artemesia*) on the shore of Fallen Leaf Lake near the Lodge

on July 5. Typical examples of *Bolteria picta* Uhler received from Mr. Heidemann show but few black hairs and they seem to be entirely wanting from specimens taken by me on the plains about Denver, Colorado.

Homoptera

Okanagana rimosa Say. Common at all levels from Fallen Leaf Lake up to 8500 feet on Angora Ridge, the first individuals appearing on July 3. This species has the habit of resting in trees fifteen or more feet above the ground, and being wary are very difficult to capture.

Okanagana ornata Van D. On July 11 I took from low oak bushes growing on the top of the lateral moraine east of Fallen Leaf Lake three male examples of a form agreeing entirely with *ornata* except that the orange colors are replaced with pale testaceous. Possibly the local conditions might account for this difference in color or these specimens may not have been fully colored.

Aphrophora permutata Uhler. Common at lower levels and first reaching maturity about July 15.

Stictocephala pacifica Van D. Not uncommon about Fallen Leaf Lake during July.

Telamona barbata Van D. On July 30 I took numbers of what may prove to be this species from a willow having pale green foliage, growing on the southern slope of Mount Tallac. These have the crest more erect and elevated than the types from New York State.

Telamona obsoleta Ball. One example of this form was beaten from a willow near Glen Alpine Springs, July 22.

Orgerius rhyparus Stål. Two fully grown examples were taken near the lower end of Fallen Leaf Lake July 17.

Elidiptera woodworthi, new species

Closely allied to *septentrionalis;* broader, more mottled with white; front whitish with its base and the clypeus fulvo-testaceous. Length 7 mm.

Vertex a little shorter than in *septentrionalis*, scarcely as long as broad, the impressed median line almost obsolete in the female. Front a little narrower than in the allied species, sides almost rectilinear, at apex curving inward to base of clypeus. Pronotum as in *septentrionalis*, narrowly produced to about the middle of the eyes and truncate at apex.

Elytra broad as in *variegata* and *pallida*. Rostrum reaching to apex of penultimate ventral segment. Hind edge of genital segment feebly arcuated in the female, quite deeply notched in the male, leaving a conspicuous lobe or tooth at the lower angle next the ventral insicure; dorsal plate of the male long and triangular at apex. In the male of *septentrionalis* the genital segment is truncated, without a ventral notch, and the dorsal plate is short and truncated, not exceeding the plates.

Color fulvo-testaceous, becoming more gray on vertex and pronotum; elytra milky-white with pale nervures, varied with testaceous-brown and dotted with fuscous, the brown forming a longitudinal series of three squarish patches on each elytron, the anterior two sometimes obscurely united by a brownish cloud along the claval suture; inner apical cells mostly brown crossed by white nervures and veinlets; the fuscous dots arranged along nervures and on costal margin, where they form two irregular marks before the apical areoles. Wings infuscated at apex. Pronotum irrorate with brown, the fulvous mesonotum more obscurely so. Beneath and legs almost uniformly fulvo-testaceous with a dark lateral vitta covering the eye and shading below to black with the extreme edge of the inferior aspect of the pronotum clear white. Front whitish, with the base to a little below the upper angle of the eye darker and irrorate with brown. Edges of the pleural pieces and ventral segments whitish.

Described from numerous examples taken on the Jeffrey pine, especially along the southern slope of Mount Tallac, after July 19. They were also beaten from cypress bushes growing on this same slope and here the young were taken with the adults. This is of a clearer gray than any of our other species of *Elidiptera*. It has much the aspect of the eastern *variegata* but that is a larger and darker form with a shorter vertex. In my key of 1907 it runs directly to *septentrionalis* but may be distinguished from that form by its more whitish aspect, broader form, the mostly pale front and the different genital characters.

Catonia nemoralis, new species

Size and aspect of *grisea*, to which it is closely related; ashy gray with the elytra irrorated and mottled with fuscous and dotted with white veinlets, the front uniformly whitish-testaceous. Length 5 mm.

Vertex short, truncate, broader than in *grisea*, not as long as width of each compartment. Pronotum at the middle scarcely as long as vertex. Mesonotum shorter than in *grisea*, about twice length of vertex and pronotum together (in *grisea* three times as long). Front broader than in *grisea*, but little wider toward clypeus. Last ventral segment of the male truncated, with a subacute triangular median tooth about one-third the length of the valves, while in *grisea* it is nearly half their length. Plates oblong, a little narrowed at apex.

Color of head, pronotum and mesonotum fulvo-testaceous, becoming more brown on mesonotum, where the dark irrorations are more conspicuous. Pronotum darkened either side of the median carina, with about four brown points behind each eye; vertex sometimes showing dark irrorations. Elytra testaceous-gray with a tinge of brown and marked with two obscure transverse brown bands, one, more distinct, at the basal third, the other at the apex of the clavus, the costa with a narrow fuscous line; all the nervures, including the costal, pale, slenderly edged with fuscous and broken by numerous white transverse veinlets. Wings fuscous at apex with darker nervures. Front and clypeus whitish-testaceous, immaculate or nearly so. Pectus and legs brown, inferior aspect of pronotum testaceous, knees, tips of the tibiae and tarsi pale. Abdomen black, white-pruinose, the slender edges of segments and genital pieces pale. Antennae brown, the setae black.

Described from numerous examples taken June 20 to the last of July from the level of Lake Tahoe up to 8000 feet. This species seems to live entirely on the lodge-pole pine, although it was occasionally captured on other trees whence it had evidently flown from the pines.

Catonia succinea, new species

Form and aspect of *majusculus;* a little smaller and nearly immaculate but closely allied to it in most of its characters; pale amber-brown above, almost white beneath. Length 6 mm.

Vertex distinctly longer than in *majusculus*, passing the eye by about one-fourth its length, anterior edge parabolic and obviously carinate; median carina prominent, abbreviated before; hind edge almost truncate. Pronotum shorter than vertex, carinae prominent. Mesonotal carinae sharp, feebly arcuate at apex. The closed elytra almost parallel, a very little wider toward their apex. Front narrower than in *majusculus*, not obviously wider at apex, carinae prominent. Last ventral segment of the male truncate at apex, without a median tooth, plates contiguous at base, oblong, oblique at apex.

Color a uniform obscure amber-brown, quite strongly tinged with fulvous on mesonotum; surface of the elytral areoles subhyaline and beautifully green-iridescent when closed over the wings. Beneath whitish, tinged with fulvous or amber on the front, clypeus, mesopleura and apex of the tarsi; lateral carinae of the front pale.

Described from twelve examples, representing both sexes, taken about the upper end of Fallen Leaf Lake and along Glen Alpine Creek during July. Most of these I beat from cypress bushes and that probably is the native food-plant of the species.

Oliarus fidus Van D. One pair taken near Glen Alpine Creek in July. These are a little larger and darker than those from San Diego County but do not seem to differ otherwise.

Cixius basalis Van D. Not uncommon during July about Fallen Leaf Lake and at Half Moon Lake. This species has been taken in the Selkirk Mountains in British Columbia and in Colorado, and is common in the northeastern states and Canada.

Laccocera obesa Van D. Several females were found on the flats at the lower end of Fallen Leaf Lake, July 17.

Liburnia magnifrons Crawf. Taken with the preceding.

Liburnia sp. A species near *osborni* was very abundant on a marshy meadow near the Angora Lakes at an altitude of 7200 feet.

Koebelia californica Baker. Abundant on lodge-pole pine. They began reaching maturity about July 12 and by the last of the month few nymphs were seen.

Koebelia irrorata Ball. One pair was taken with the preceding on July 22. It is larger, with a longer vertex, and is paler in color and less mottled, and the genital characters are distinct.

Oncopsis variabilis Fitch. On alders about the upper end of Fallen Leaf Lake, July 5 to 19. These are all pale yellow or testaceous and are without the oblique elytral vitta. One male does not differ from the female in color.

Oncopsis pruni Prov. Two males taken at Half Moon Lake and one near Cathedral Lake, July 5.

Idiocerus amoena Van D. Taken at the lower levels during July.

Agallia californica Baker. Angora Lake, June 22, and Fallen Leaf Lake, July 16.

Helochara communis Fitch. Lower end of Fallen Leaf Lake, not uncommon.

Xerophloea viridis Fabr. One large rather gray specimen was taken with the preceding.

Gypona angulata Spangb. A single specimen taken near Glen Alpine Springs, July 12.

Errhomenellus maculatus G. & B. Two young and two adults of what I believe to be this species were taken along the Tallac short trail, July 5.

Paraboloeratus viridis Uhler. Several were found near the sawmill at the lower end of Fallen Leaf Lake, July 17.

Aligia jucunda Uhler. Beaten from chinquapin oaks on the western short of Fallen Leaf Lake, July 5.

Aligia inscripta Van D. Taken with the preceding and on the southern slope of Mount Tallac.

Deltocephalus affinis G. & B. Flats at lower end of Fallen Leaf Lake, July.

Deltocephalus vanduzei G. & B. Not uncommon on the low lands and on the meadow near the Angora Lakes.

Deltocephalus punctatus O. & B. Two taken near Fallen Leaf Lake. This seems to be scarcely more than a pale form of *fuscinervosus*.

Phlepsius ovatus Van D. Taken at the lower end of Lake Tahoe, July 17.

Phlepsius occidentalis Baker. Lower end of Fallen Leaf Lake, July 25.

Euscelis exitiosus Uhler. Common up to 7500 feet.

Euscelis striolus Fall. One example was taken on the meadows near the Hotel Tallac, July 31.

Thamnotettix geminata Van D. Common about the lower end of Fallen Leaf Lake in July.

Thamnotettix longiseta Van D. Two examples taken with the preceding.

Cicadula laeta Uhler. One pair taken with the foregoing, July 17.

Cicadula sexnotata Fall. Abundant about the Angora Lakes, Half Moon Lake and Grass Lake. Here as elsewhere it lives on fine grasses growing near water or in damp situations.

Balclutha impicta Van D. Two females were taken in a swampy meadow at the foot of Angora trail in July.

Eugnathodus abdominalis Van D. Not uncommon in fields about Hotel Tallac during July.

Dicraneura carneola Stål. Abundant in a swampy meadow near the Angora Lakes and more rarely in grassy places about Fallen Leaf Lake and Grass Lake.

Empoa commissuralis Stål. Near Glen Alpine Creek, three examples.

Aphalara calthae Linn. Beaten from chaparral along the western shore of Fallen Leaf Lake in July.

Euphyllura arbuticola Crawf. Three examples taken with the preceding.

Euphyllura nevadensis Crawf. Common on *Ceanothus* with the preceding.

Transmitted March 20, 1916.

UNIVERSITY OF CALIFORNIA PUBLICATIONS
TECHNICAL BULLETINS
COLLEGE OF AGRICULTURE, AGRICULTURAL EXPERIMENT STATION
ENTOMOLOGY
Vol. 1, No. 6, pp. 251-299 June 17, 1916

Smithsonian Institution,
JUN 27 1916
National Museum.

LIFE-HISTORY AND FEEDING RECORDS OF A SERIES OF CALIFORNIA COCCINELLIDAE

BY

CURTIS P. CLAUSEN

UNIVERSITY OF CALIFORNIA PRESS
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CURTIS P. CLAUSEN

The studies herein outlined of a series of California Coccinellidae were undertaken by the writer at Sacramento, California, during the spring and summer of 1913, and concluded at Berkeley and Riverside during the season of 1914. Due to the change of locality, a certain unavoidable lack of continuity was made necessary, and the variable contributing factors of temperature, humidity, aphis supply, etc., were thus more strongly accentuated than would have been the case had the experiment with the different species been conducted simultaneously under definite and regular conditions. A further discussion of this matter will be presented in connection with the particular cases as they arise.

The coccinellid species used for the tests are all of fairly general distribution over the state, and in general may be said to be the eight most important aphis-eating species in California. They are: *Hippodamia convergens* Guer., *Hippodamia ambigua* Lec., *Coccinella californica* Man., *Coccinella trifasciata* Linn.,

* Paper No. 14, Citrus Experiment Station, College of Agriculture, University of California, Riverside, California.

The investigation of this problem was begun and largely completed by the writer while field assistant in the Bureau of Entomology under the immediate direction of Mr. W. B. Parker, and concluded while in the service of the University of California. Permission for publication has been granted by Dr. L. O. Howard, Chief of the Bureau of Entomology, United States Department of Agriculture.

Olla oculata Fab., *Olla abdominalis* Say, *Cycloneda sanguinea* Linn., and *Adalia bipunctata* Linn.

The writer makes no assertions with respect to the validity of any of the above-named species. The belief is quite general that *Hippodamia ambigua* is a varietal form of *Hippodamia convergens*, and the same claim has been advanced regarding *Olla abdominalis* with respect to *Olla oculata*. Investigations are now under way to determine the exact status of these forms.

Laboratory Methods

At the time the investigations were undertaken an extensive series of tests was made to determine the most satisfactory method of caging the individuals during the period covered by the experiment, in order to secure as nearly as possible ideal conditions. Potted plants infested with aphis and covered with chimney glasses were used for a time, but did not fulfill the requirements, due to the fact that moisture often collected on the inside of the glass, and also because the adult beetles showed a strong tendency to ascend to the top of the glass and there remain inactive, rather than to feed normally on the infested plant as desired. Later plaster of paris containers, jelly glasses, etc., were used but with indifferent success. By far the best results were finally secured by confining the individuals under observation in ordinary three-inch vials with cotton stoppers. Experiments upon larvae necessitated the covering of the stoppers with thin tissue-paper to prevent injury through entanglement in the cottony fibers. The stoppers used were light enough to permit a reasonably free passage of air, thus maintaining approximately outdoor conditions as regards temperature and humidity.

In the feeding tests, both with larvae and adults, a certain definite number of aphids of as nearly a standard size as possible were placed in each vial early in the morning and the count made at the corresponding time the following day. The number of live aphids present was determined, and this number subtracted from the original number gave the total for the day. Check vials containing one hundred aphids each were also maintained to determine the approximate mortality from natural causes, and the proportion determined subtracted from the total of all records for the current day.

In the experiments conducted at Sacramento the hop aphis (*Phorodon humuli*) was used for all feeding purposes, unless the contrary is stated. At Berkeley and Riverside the rose aphis (*Macrosiphum rosae*) was used. More difficulty was here experienced in securing a standard size than was the case with the hop aphis. As nearly as possible individuals approximately two-thirds the maximum size of the adults of the species were used, in order to obviate the possibility of the production of young during the day.

In the life-history experiments, observations were ordinarily made once each day and the cast larval skins removed. The moult was credited in each case to the day upon which the exuvium was removed, as it was impracticable to make observations corresponding to fractional days. The date of pupation was recorded upon the day during which the median dorsal split appeared in the fourth larval skin, even though this may have taken place several days after the larva, having ceased feeding, attached itself to some solid base, and assumed the general appearance and form of the pupa.

In order to secure complete egg records it was found necessary to make the count and remove all eggs three times each day, because of the strong tendency of the females at times to devour their own eggs, even though an adequate supply of food was present at all times.

In the tabulations as given in this paper the following symbols have been used to designate certain things. They are as follows:

L = Eggs deposited
H = Hatched
* = Moulted, or death of male
P = Pupated
E = Emerged
M = Mated
D = Dead
C = From cold storage

Coccinella californica Mann.

The individuals of this species are the largest in size of any of the common California coccinellids, the fully developed larvae measuring 10.2 mm. and the adult beetles approximately 8.0 mm. The elytra of the adult normally exhibit no markings of any kind, yet specimens have been found which exhibited spots of

various sizes and in no definite position. Upon rearing the progeny of these individuals it was found that to a considerable extent the offspring bore the characteristic markings of the parents.

Oviposition.—Upon the basis of observing ten individuals, a period of time varying from two to three days was found to intervene between emergence and mating, while from mating to egg-laying the time elapsing varied from ten to fourteen days, with an average of 11.9 days. As regards the period of oviposition, a range of from 20 to 51 days was found, averaging 31 days. During these periods the proportion of days upon which eggs were laid varied from 60.0 to 74.1 per cent, with an average of 69.5 per cent. The maximum number of eggs laid in one day was 24, the maximum number of eggs for the period was 360, and the minimum 127, thus giving a daily average of 8.0 eggs and a period average of 247 eggs.

Egg-Laying Records—*Coccinella californica* Mann.

Berkeley, 1914

Date	1	2	3	4	5	6	7	8	9	10
April 6	.....	E	.....	.....	E	.....	.....	.....	E	.....
7	.....	.....	E	E	.....	.....	E	.....	.....	E
8	E	.....	.....	.....	M	.....	.....	E	.....	.....
9	.....	M	M	M	.....	E	.....	.....	M	M
10	M	.....	.....	.....	.....	.....	M	M	.....	.....
11	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
12	.....	.....	.....	.....	.....	M	.....	.....	.....	.....
13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
14	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
16	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
17	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
18	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
19	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
20	.....	.....	6	.....	.....	.....	.....	.....	.....	.....
21	5	.....	10	.....	6	.....	.....	.....	8	.....
22	.....	2	12	.....	5	.....	.....	.....	.....	.....
23	8	.....	8	4	9	3	.....	5	4	.....
24	3	5	14	8	4	16	9	14	.....	11
25	7	16	6	.....	13	5	7	8	13	6
26	.....	4	11	13	.....	8	11	.....	7	.....
27	.....	10	.....	10	16	.....	4	6	.....	18
28	12	.....	16	.....	8	1	13	9	11	5
29	14	8	.....	17	.....	6	.....	10	10	14
30	.....	19	14	6	19	.....	8	.....	7	.....

Egg-Laying Records—*Coccinella californica* Mann.—(*Continued*)

Berkeley, 1914

Date	1	2	3	4	5	6	7	8	9	10
May 1	9	21	7	.....	.....	12	17	5	16	12
2	.....	.....	21	11	11	14	.....	21	.....	8
3	17	6	13	19	15	9	16	.....	12	11
4	24	18	.....	21	.....	17	9	14	9	15
5	12	.....	5	.....	20	.....	12	17	.....	.....
6	16	10	14	18	.....	22	.....	7	16	9
7	18	5	7	16	14	8	8	.....	.....	4
8	10	.....	18	5	.....	4	.....	11	10	3
9	.....	11	.....	7	.....	.....	14	.....	.....	12
10	6	14	9	.....	19	15	7	21	4	.....
11	18	.....	13	11	5	17	6	.....	.....	8
12	.....	6	3	.....	10	11	15	16	D	16
13	9	.....	15	3	8	.....	4	8	.....	14
14	23	3	.....	.....	.....	8	.....	4	.....	.....
15	8	.....	6	.....	.....	12	17	.....	.....	9
16	.....	11	14	2	16	.....	8	13	.....	1
17	13	.....	12	D	.....	10	.....	10	.....	20
18	.....	4	9	.....	19	4	21	8	.....	8
19	15	D	.....	.....	9	.....	6	12	.....	5
20	14	.....	8	.....	.....	3	14	.....	.....	.....
21	9	.....	.....	.....	.....	D	.....	17	.....	13
22	3	.....	16	.....	12	.....	.....	6	.....	.....
23	.....	.....	14	.....	.....	.....	10	.....	.....	17
24	10	.....	23	.....	10	.....	.....	3	.....	8
25	15	.....	.....	.....	18	.....	9	D	.....	3
26	12	.....	12	.....	4	.....	.....	.....	.....	.....
27	.....	.....	8	.....	21	.....	.....	.....	.....	5
28	13	.....	.....	.....	.....	.....	D	.....	.....	16
29	7	.....	D	.....	11	.....	.....	.....	.....	.....
30	.....	.....	.....	.....	.....	.....	.....	.....	.....	D
31	5	.....	.....	.....	9	.....	.....	.....	.....	.....
June 1	D	.....	.....	.....	3	.....	.....	.....	.....	.....
2	.....	.....	.....	.....	0	.....	.....	.....	.....	.....
3	.....	.....	.....	.....	16	.....	.....	.....	.....	.....
4	.....	.....	.....	.....	5	.....	.....	.....	.....	.....
5	.....	.....	.....	.....	0	.....	.....	.....	.....	.....
6	.....	.....	.....	.....	14	.....	.....	.....	.....	.....
7	.....	.....	.....	.....	0	.....	.....	.....	.....	.....
8	.....	.....	.....	.....	0	.....	.....	.....	.....	.....
9	.....	.....	.....	.....	8	.....	.....	.....	.....	.....
10	.....	.....	.....	.....	0	.....	.....	.....	.....	.....
11	.....	.....	.....	.....	3	.....	.....	.....	.....	.....
12	.....	.....	.....	.....	D	.....	.....	.....	.....	.....
Total	335	173	344	171	360	205	245	245	127	271
Average	8.1	6.4	8.8	7.1	6.9	7.3	7.2	7.6	6.0	7.5

Life-History.—The records of thirteen individuals give the average hatching period during normal summer conditions as 5.4 days, the second period from two to five days, the third period from three to four days, the fourth period from five to eight days, and the pupal period from four to six days. The averages for these periods were 5.7, 3.3, 3.4, 6.8, and 4.5 days, respectively, which, in connection with the egg stage of 5.4 days, gave an average life-cycle of 29.1 days. A rather peculiar variation is noted in Nos. 1 and 2, in which case the first larval period was lengthened to eight to ten days, respectively, which is an increase of three to five days over the normal of five days as represented by the ten other individuals. No noticeable variations appeared in the later stages and the life-history of the first individual was complete in 31 days, or slightly less than two days over the normal. No appreciable difference in size was noted. Individual No. 2, referred to above, died shortly after pupation. In the case of nearly all individuals, a period of from one to three days elapsed from the time feeding ceased until the last larval skin was cast. This is the only species in which this period of inactivity was so uniform and pronounced.

Life-History—*Coccinella californica* Mann.
Sacramento, 1913

No.	Date eggs laid	Eggs hatched	Length of stage, days	1st moult	Length of stage, days	2d moult	Length of stage, days	3d moult	Length of stage, days	4th moult (pupation)	Length of stage, days	Emerged	Length of pupal stage, days	Total days of stages
1	5/1	5/7	6	5/15	8	5/20	5	5/23	3	5/29	5	6/3	4	31
2	5/1	5/7	6	5/17	10	5/21	4	5/24	3	5/31	7	(D)	....	....
3	6/3	6/8	5	6/13	5	6/17	4	6/20	3	6/28	8	7/2	4	29
4	6/3	6/8	5	6/13	5	6/16	3	6/20	4	6/26	6	7/1	5	28
5	6/3	6/8	5	6/13	5	6/17	4	6/20	3	6/27	7	7/2	5	29
6	6/3	6/8	5	6/13	5	6/16	3	6/20	4	6/26	6	7/1	5	28
7	6/3	6/8	5	6/13	5	6/17	4	6/19	4	6/27	8	7/2	5	29
8	6/3	6/8	5	6/13	5	6/17	4	6/20	3	6/27	7	7/2	5	29
9	6/3	6/8	5	6/13	5	6/16	3	6/20	4	6/26	6	7/2	6	29
10	6/5	6/11	5	6/17	6	6/19	2	6/22	3	6/29	7	7/4	5	29
11	6/5	6/11	6	6/16	5	6/18	2	6/22	4	6/29	7	7/4	5	29
12	6/5	6/11	6	6/16	5	6/18	2	6/22	4	6/29	7	7/4	5	29
13	6/5	6/11	6	6/16	5	6/19	3	6/22	4	6/29	7	7/4	5	30
Average			5.4		5.7		3.3		3.4		6.8		4.5	29.1

Feeding Habits.—The larvae of this species, as would be expected, consumed by far the largest number of aphids as compared with those of other species during its period of life. The records of thirteen individuals give a daily feeding average of 24.9 aphids, while for the entire period the maximum reached 600 and the minimum 394, the average for all individuals being 475 aphids during the larval period of approximately 24 days.

The unusual number recorded for May 22–23 was due to the excessive heat, all the aphids in the check vials being dead upon these dates. It was not possible therefore to make a proportionate reduction in the individual totals.

Larval Feeding Records—*Coccinella californica* Mann.
Sacramento, 1913

Date	1	2	Date	3	4	5	6	7	8	9	10	11	12	13
May 7	H	H	June 8	H	H	H	H	H	H	H	H	.....	.....	.....
8	2	1	9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
9	5	5	10	1	2	2	1	3	2	3	1	.....	.....	.....
10	3	4	11	3	4	2	3	2	4	5	3	H	H	H
11	4	4	12	4	4	4	7	6	4	8	6	0	1	0
12	7	6	13	6*	4*	5*	4*	6*	2*	4*	6*	3	3	1
13	9	9	14	9	5	6	6	8	8	6	8	2	4	4
14	5*	4	15	11	9	12	8	7	9	11	7	3	3	5
15	8	8	16	9	11*	7*	9*	8	9	6*	7*	5*	7*	4*
16	13	9*	17	13*	11	15	13	10*	10*	14	13	9	8	8
17	14	10	18	24	18	23	13	21	22	23	24	9	9*	6*
18	6	11	19	30	19	27	25*	28	32	28	31	16*	20	17
19	14*	9	20	29*	34*	31*	37	33*	37*	37*	37*	21	17	21
20	17	7*	21	41	49	51	48	48	43	51	49	27	25	27
21	19	13	22	97	92	88	100	92	96	87	92	66	69	72*
22	20*	25	23	125	125	125	125	125	125	125	125	79	87*	83
23	46	26*	24	82	54	74	51	26	41	63	47	57*	69	59
24	79	43	25	41	.....	.....	.....	D	.....	.....	.....	83	74	76
25	127	109	26	.....	P	.....	P	.....	.....	.....	P	86	66	49
26	37	63	27	.....	.....	P	.....	.....	P	P	.....	54	93	53
27	.....	28	28	P	.....	.....	.....	.....	.....	.....	.....	49	45	43
28	P	.....	29	.....	.....	.....	.....	.....	.....	.....	.....	P	P	P
29	.....	.....	30	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
30	.....	P	July 1	.....	E	.....	E	.....	.....	.....	.....	.....	.....	.....
31	.....	.....	2	E	.....	E	.....	.....	E	E	E	.....	.....	.....
June 1	.....	D	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2	E	.....	4	.....	.....	.....	.....	.....	.....	.....	.....	E	E	E
Total	435	394		525	441	472	450	423	444	471	456	569	600	528
Average	22.9	19.7		32.8	29.4	31.4	30.0	28.2	29.6	31.4	30.4	35.5	35.3	33.0

Ten adults during a fifteen-day period consumed an individual maximum of 661 aphids and a minimum of 414, with an average for the series of 500 aphids. Upon a daily basis this would be 34.0 aphids per day. During the period the number eaten daily ranged from 16 to 62, which is considerably lower than the record of *Hippodamia convergens,* a condition not to be expected from the relative sizes of the individuals of the two species. This numerical relationship is not evident in the case of the larvae, and the difference may in all probability be attributed to the variation in climatic conditions existing at Sacramento and at Riverside, California. In this experiment the rose aphis (*Macrosiphum rosae*) was used exclusively.

Adult Feeding Records—*Coccinella californica* Mann.

Riverside, 1914

Date	1	2	3	4	5	6	7	8	9	10
Sept. 26	31	41	26	37	34	42	18	37	35	24
27	26	33	29	30	25	26	29	26	29	30
28	47	28	41	21	41	35	23	18	45	19
29	49	51	37	29	49	17	41	36	34	28
30	62	29	35	43	53	24	36	24	52	39
Oct. 1	51	43	23	20	40	29	20	18	37	23
2	29	47	41	28	32	32	17	29	34	27
3	58	54	32	26	47	27	33	27	43	32
4	47	35	60	42	36	41	21	42	29	17
5	39	44	28	31	25	36	26	18	38	45
6	42	26	33	37	16	21	18	33	52	42
7	26	38	41	25	34	28	35	15	26	36
8	51	47	39	34	29	35	32	41	44	24
9	57	42	35	38	26	19	46	28	39	30
10	46	51	39	24	37	24	33	22	37	52
Total	661	609	529	465	524	436	428	414	574	468
Average	44.0	40.6	35.2	31.	34.9	29.0	28.5	27.6	38.2	31.2

Coccinella trifasciata Linn.

This species is not of any great importance in California because it occurs only in limited numbers in most sections, though in the San Francisco Bay Region it may be found in very considerable numbers, at times to an extent even greater than *Hippodamia convergens.* The adults ordinarily pass the winter singly, hidden away in bunches of grass, leaves, and in other protected places. This is one of the first species to appear in the

spring, and in several cases observed has done good work in the control of the rose aphis.

Oviposition.—No records were secured of the time intervening between emergence, mating, and egg-laying. The period of oviposition extended in one case over 42 days, while the average for ten specimens was 29.2 days. During the period the proportion of days upon which oviposition occurred ranged from 66.6 to 78.1 per cent, with a general average of 75.0 per cent, which indicates a quite general uniformity in this respect. The maximum number of eggs deposited by an adult was 369, the minimum 109, and the average 249 eggs; the maximum number deposited in one day was 31, while the average for all individuals was 8.4, with a range of from 4.7 eggs to 10.4 per day. It will be observed from the following table that the individuals depositing the largest number of eggs, as a general rule also gave the highest daily record.

Egg-Laying Records—*Coccinella trifasciata* Linn.
Berkeley, 1914

Date	1	2	3	4	5	6	7	8	9	10
Apr. 18	.....	.....	.....	.....	1	.....	.....	.....	.....	.....
19	.....	.....	.....	.....	5	.....	.....	.....	.....	.....
20	.....	.....	.....	.....	10	.....	.....	.....	.....	.....
21	7	.....	2	.....	7	.....	.....	.....	.....	.....
22	8	.....	5	.....	13	.....	18	.....	.....	.....
23	.....	12	.....	.....	2	.....	7	.....	.....	.....
24	12	15	11	5	.....	.....	12	.....	12	.....
25	9	9	8	7	6	.....	9	.....	8	.....
26	13	22	6	4	13	2	14	.....	13	.....
27	.....	6	.....	3	.....	13	.....	9	.....	3
28	11	8	3	11	5	11	3	23	16	8
29	.....	2	7	9	17	20	16	16	7	.....
30	21	.....	11	.....	3	.....	9	.....	19	13
May 1	18	.....	.....	5	.....	18	.....	13	12	9
2	15	13	14	2	1	6	18	8	6	.....
3	6	9	.....	14	.....	5	20	6	32	19
4	12	.....	.....	6	9	.....	.....	.....	7	.....
5	2	17	8	.....	16	12	.....	14	.....	30
6	.....	.....	5	8	4	.....	14	.....	.....	5
7	25	21	.....	12	.....	17	8	17	12	17
8	22	13	16	.....	5	16	19	6	18	.....
9	14	23	.....	.....	11	23	11	2	23	16
10	9	.....	6	9	.....	8	5	.....	1	21
11	.....	8	.....	.....	16	.....	.....	D	.....	6
12	4	15	5	13	23	15	7	.....	9	9
13	7	12	.....	17	15	7	.....	.....	13	.....

Egg-Laying Records—*Coccinella trifasciata* Linn.—(*Continued*)

Berkeley, 1914

Date	1	2	3	4	5	6	7	8	9	10
14	.....	17	2	21	21	13	19	.....	.....	2
15	9	.....	D	12	6	.....	31	.....	16	.....
16	14	13	.....	6	D	9	20	.....	.....	D
17	7	5	.....	18	.....	.....	7	.....	.....	.....
18	15	6	.....	.....	.....	12	.....	.....	19	.....
19	.....	3	.....	13	.....	5	16	.....	6	.....
20	9	.....	.....	17	.....	.....	26	.....	3	.....
21	.....	2	.....	12	.....	19	21	.....	.....	.....
22	22	D	.....	20	.....	4	8	.....	12	.....
23	8	.....	.....	.....	.....	8	2	.....	8	.....
24	13	.....	.....	16	.....	.....	7	.....	13	.....
25	16	.....	.....	7	.....	3	6	.....	.....	.....
26	9	.....	.....	13	.....	12	.....	.....	12	.....
27	7	.....	.....	12	.....	14	D	.....	6	.....
28	.....	.....	.....	.....	.....	2	.....	.....	.....	.....
29	5	.....	.....	.....	.....	9	.....	.....	17	.....
30	D	.....	.....	7	.....	1	.....	.....	5	.....
31	.....	.....	.....	3	.....	D	.....	.....	.....	.....
June 1	.....	.....	.....	1	.....	.....	.....	.....	8	.....
2	.....	.....	.....	D	.....	.....	.....	.....	16	.....
3	.....	.....	.....	.....	.....	.....	.....	.....	3	.....
4	.....	.....	.....	.....	.....	.....	.....	.....	1	.....
5	.....	.....	.....	.....	.....	.....	.....	.....	D	.....
Total	349	251	109	303	209	284	353	114	353	158
Average	8.9	8.6	4.5	7.7	7.4	8.1	10.0	8.1	8.4	8.3

Life-History.—The entire series of individuals used in this test was secured from a cluster of eggs deposited by one female on April 20. These hatched six days later and the adult beetles emerged in from 23 to 29 days. The first larval period, with three exceptions, required five days, the second three to five days, the third from three to four days, the fourth six to eight days, and the pupal period from five to seven days. The average for twelve individuals for the entire cycle from egg to adult was 31.8 days.

Feeding Habits.—With complete feeding records of twelve larvae as a basis of comparison, it was found that the total number of aphids eaten varied from 217 to 375, and averaged 294. This, when reduced to a daily basis, represented 15.8 aphids per day during the stage of approximately 26 days.

Life-History—*Coccinella trifasciata* Linn.

Berkeley, 1914

No.	Date eggs laid	Eggs hatched	Length of stage, days	1st moult	Length of stage, days	2d moult	Length of stage, days	3d moult	Length of stage, days	4th moult (pupation)	Length of stage, days	Emerged	Length of pupal stage, days	Total days of stages
1	4/20	4/26	6	5/1	5	5/4	3	5/7	3	5/14	7	5/20	6	30
2	4/20	4/26	6	5/1	5	5/4	3	5/7	3	5/14	7	5/14	5	29
3	4/20	4/26	6	5/1	5	5/5	4	5/8	3	5/16	8	5/21	5	31
4	4/20	4/26	6	5/1	5	5/5	4	5/8	3	5/15	7	5/21	6	31
5	4/20	4/26	6	5/1	5	5/5	4	5/8	3	5/14	6	5/19	5	29
6	4/20	4/26	6	5/1	5	5/5	4	5/9	4	5/16	7	5/22	6	32
7	4/20	4/26	6	5/2	6	5/7	5	5/10	3	5/18	8	5/25	7	35
8	4/20	4/26	6	5/1	5	5/6	5	5/10	4	5/17	7	5/23	6	33
9	4/20	4/26	6	5/2	6	5/6	4	5/9	3	5/17	8	5/22	5	32
10	4/20	4/26	6	5/2	6	5/6	4	5/9	3	5/17	8	5/22	5	32
11	4/20	4/26	6	5/1	5	5/6	5	5/10	4	5/18	8	5/24	6	34
12	4/20	4/26	6	5/1	5	5/6	5	5/9	3	5/17	8	5/23	6	33
			—		—		—		—		—		—	—
Average			6		5.25		4.2		3.25		7.4		5.7	31.8

The adult records are given for ten individuals for a fifteen-day period; the number of aphids eaten per day ranged from 6 to 44 per day. The period totals varied from 383 to 470, with an average of 435. The feeding, with the exception of an occasional day, was very uniform, due no doubt to the evenness of the temperature conditions during the time covered by the experiment.

Medium-sized rose aphids (*Macrosiphum rosae*) were used for feeding purposes.

Larval Feeding Records—*Coccinella trifasciata* Linn.

Berkeley, 1914

Date	1	2	3	4	5	6	7	8	9	10	11	12
April 26	H	H	H	H	H	H	H	H	H	H	H	H
27	0	2	2	1	1	0	1	2	3	0	1	3
28	3	2	1	3	2	1	3	2	5	2	1	5
29	4	6	5	7	8	4	5	3	6	4	3	4
30	7	8	7	9	10	6	4	7	4	6	5	8
May 1	8*	5*	6*	10*	11*	7*	6	9*	5	7	10*	6*
2	7	8	8	12	5	9	11*	6	8*	10*	9	11
3	10	9	11	14	7	12	13	9	7	13	9	14
4	9*	16*	15	7	12	14	8	21	15	18	11	17
5	12	14	13*	12*	18*	9*	16	14	8	12	16	15
6	11	17	16	8	13	17	21	13*	16*	12*	24*	9*

Larval Feeding Records—*Coccinella trifasciata* Linn.—(*Continued*)

Berkeley, 1914

Date	1	2	3	4	5	6	7	8	9	10	11	12
May 7	14*	18*	22	17	20	16	25*	12	18	15	23	14
8	12	16	19*	19*	18*	23	22	18	23	31	17	19
9	21	24	20	23	31	27*	18	16	27*	29*	21	23*
10	27	22	31	18	26	25	23*	21*	31	26	30*	27
11	23	31	25	17	29	19	27	30	19	33	26	22
12	20	24	15	26	25	16	24	18	26	31	29	26
13	29	27	22	34	30	23	34	26	29	28	17	33
14	P	P	24	17	P	32	27	32	18	19	32	19
15	.....	.....	7	P	.....	19	19	28	25	31	37	22
16	.....	.....	P	.....	.....	P	8	17	36	23	25	16
17	.....	.....	.....	.....	.....	.....	P	P	P	P	19	P
18	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	P	.....
19	.....	E	.....	.....	E	.....	.....	.....	.....	.....	.....	.....
20	E	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
21	.....	.....	E	E	.....	.....	.....	.....	.....	.....	.....	.....
22	.....	.....	.....	.....	.....	E	.....	.....	E	E	.....	.....
23	.....	.....	.....	.....	.....	.....	.....	E	.....	.....	.....	E
24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	E	.....
25	.....	.....	.....	.....	.....	.....	E	.....	.....	.....	.....	.....
Total	217	249	269	254	266	279	315	304	329	350	365	313
Average	13.5	14.6	14.1	14.1	15.6	15.5	15.7	15.2	16.4	18.4	17.3	15.6

Adult Feeding Records—*Coccinella trifasciata* Linn.

Berkeley, 1914

Date	1	2	3	4	5	6	7	8	9	10
May 2	27	38	32	21	34	27	31	18	36	29
3	32	25	35	19	32	29	37	23	34	23
4	29	23	12	32	19	22	17	15	39	18
5	19	31	18	26	17	30	12	36	27	26
6	37	33	19	31	22	26	6	18	31	22
7	34	29	30	29	18	37	14	22	23	27
8	30	37	25	38	31	34	18	29	30	32
9	36	36	37	22	24	42	36	25	25	37
10	35	19	32	27	30	26	29	33	37	43
11	31	28	44	24	28	32	30	30	26	22
12	20	33	26	36	27	39	24	28	21	30
13	37	39	37	41	19	28	33	29	29	36
14	34	28	31	33	37	27	42	37	31	18
15	28	31	38	35	28	33	28	26	33	24
16	39	35	23	30	17	38	31	38	27	31
Total	468	465	439	444	383	470	388	407	449	418
Average	31.2	31.0	29.2	29.6	25.5	31.3	25.8	27.1	29.9	27.8

Hippodamia convergens Guer.

The twelve-spotted coccinellid (*H. convergens*) is very generally distributed throughout the state and is by far the most important member of the coccinellid group as regards aphis control by natural means. This species is shipped by the millions into Imperial Valley each spring for the purpose of combating the melon aphis (*Aphis gossypii*). During the late summer and fall months the adult beetles gather in great colonies in mountain cañons and other cool and protected places, and may be found in great quantities among the dead leaves and brush or clustered upon rocky surfaces.

The aphids upon which this coccinellid feeds are extensive in number, but the main species infesting cultivated plants are the hop aphis (*Phorodon humuli*), the rose aphis (*Macrosiphum rosae*), the beet louse (*Pemphigus betae*), the oleander aphis (*Aphis nerii*), the bean aphis (*Aphis rumicis*), the plum aphis (*Hyalopterus arundinis*), and the melon aphis (*Aphis gossypii*). Feeding has been observed to a comparatively limited extent upon the walnut aphis (*Chromaphis juglandicola*), the woolly apple aphis (*Schizoneura lanigera*), and the cabbage aphis (*Aphis brassicae*). The elm aphis, though very numerous, was very seldom attacked.

The Egg.—The eggs of *H. convergens* are 1.4 mm. long, spindle-shaped, and bright yellow in color, and are deposited vertically in groups of ten to thirty on the under sides of leaves and in other sheltered and protected places. A short time previous to the time of hatching, the egg loses its bright yellow color and assumes a grayish tint. The emergence of the young larva ordinarily takes place in the course of the day during which this change occurs. In the great majority of cases all the eggs of a given cluster will hatch within the period of one hour, but occasionally the intervening period may be considerably longer, in which case the larva first emerging may devour the contents of the remainder of the cluster.

In order to determine the approximate percentage of fertile eggs among the total deposited four hundred were collected from the foliage of a prune tree and an accurate count made of the emerging larvae. A total of 332, or 83 per cent, was secured. Of those failing to hatch, a few were broken by young larvae,

but the great majority were sterile, as was evidenced by their shrinkage in size and the loss of the bright color characteristic of fertile eggs.

The Larva.—The larva emerges from the egg through an apperture of irregular outline across the upper end. For a period of from fifteen minutes to half an hour or more it remains with the body protruding vertically about two-thirds of the way out of the shell, during which time the body becomes hardened sufficiently to permit locomotion. At this time the larva is bright yellow in color but gradually assumes the markings characteristic of the species. Twelve to twenty-four hours usually elapse before feeding commences, the larvae in the meantime remaining grouped upon or in the immediate vicinity of the cluster of broken shells.

The Pupa.—At the time of discarding the fourth larval skin the pupa is bright yellow in color, but in the course of one to three days, depending upon the conditions of temperature and light, the dark reddish brown base color with the black spots is developed. At the time of emergence the pupal skin breaks at the median line of the thorax and the adult beetle pushes its way out.

The Adult.—At the time of emergence from the pupal skin the adult is a uniform yellow over the entire surface of the body with the exception of the head, which is black. The natural color appears within the course of a few hours, becoming considerably darker, however, after one or two days. Temperature and light apparently are very strong contributing factors as regards the degree of color development.

Oviposition.—Full records of oviposition were secured of six females taken from cold storage at Sacramento, California, May 2, 1913, and of five females reared from pupae collected at Berkeley, California, during the latter part of March, 1914. Mating took place between beetles from storage from one to ten days later, the average intervening period being 4.5 days. The time elapsing between mating and oviposition varied from eight to thirteen days, with an average for the six specimens of 10.5 days.

The length of the period of oviposition as determined from eleven individuals varied from 11 to 50 days, averaging 33.3 days. Within these periods the proportion of days upon which eggs were actually deposited extended from 28 to 72.7 per cent, with an average of 63.8 per cent.

The maximum number of eggs deposited by a single individual was 609, and the minimum 94, with an average for the eleven specimens of 299. The daily averages ranged from 5.9 to 15, with a general average of 8.9 eggs per day. The maximum number deposited by a single individual upon any one day was 43 eggs.

Egg-Laying Records—*Hippodamia convergens* Guer.

	Sacramento, 1913							Berkeley, 1914					
Date	1	2	3	4	5	6	Date	7	8	9	10	11
May 2	C	C	C	C	C	C	March 24	.....	.....	.....	.....	.....
3	.....	.....	.....	.....	.....	.....	25	.....	.....	.....	.....	.....
4	.....	.....	.....	.....	.....	.....	26	.....	3	.....	.....	.....
5	.....	.....	.....	.....	.....	.....	27	.....	.....	.....	.....	12
6	.....	.....	.....	.....	.....	.....	28	12	19	.....	.....	.....
7	.....	.....	.....	.....	.....	.....	29	9	27	.....	.....	9
8	.....	.....	.....	.....	.....	.....	30	.....	16	.....	.....	14
9	.....	.....	.....	.....	.....	.....	31	8	.....	9	.....	.....
10	.....	.....	.....	.....	.....	.....	April 1	13	.....	.....	.....	.....
11	.....	.....	.....	.....	.....	.....	2	27	12	13	.....	17
12	7	.....	3	.....	.....	.....	3	.....	8	.....	.....	.....
13	.....	.....	2	.....	.....	.....	4	15	.....	.....	.....	10
14	8	.....	3	.....	.....	.....	5	.....	16	10	15	.....
15	.....	.....	.....	.....	.....	.....	6	19	.....	16	9	.....
16	.....	.....	10	.....	.....	.....	7	8	20	.....	12	18
17	.....	.....	19	.....	.....	.....	8	.....	.....	5	.....	22
18	.....	.....	15	.....	.....	16	9	21	.....	.....	.....	14
19	.....	.....	10	.....	.....	.....	10	26	23	20	8	6
20	.....	.....	15	18	.....	21	11	12	22	.....	17	20
21	.....	5	5	9	.....	.....	12	.....	17	19	22	19
22	27	14	.....	14	.....	.....	13	30	34	6	.....	31
23	4	27	12	17	.....	.....	14	19	.....	12	27	17
24	17	20	.....	36	.....	16	15	22	16	.....	21	5
25	14	16	.....	12	21	.....	16	8	29	13	10	13
26	13	43	.....	28	.....	.....	17	.....	6	.....	7	.....
27	.....	.....	.....	.....	.....	.....	18	3	12	.....	12	12
28	19	.....	D	.....	.....	.....	19	15	31	.....	.....	6
29	12	11	.....	.....	25	22	20	.....	8	.....	23	18
30	13	24	.....	4	.....	23	21	12	5	17	16	.....
31	11	30	.....	3	.....	7	22	.....	19	10	12	10
June 1	22	8	.....	D	.....	.....	23	28	.....	.....	4	.....
2	13	29	.....	.....	18	.....	24	17	29	22	10	9
3	28	15	.....	.....	.....	.....	25	26	24	.....	5	23
4	22	28	.....	.....	8	14	26	.....	8	4	9	.....
5	.....	17	.....	.....	.....	15	27	12	.....	.....	15	.....
6	20	9	.....	.....	22	.....	28	.....	30	.....	.....	17
7	21	16	.....	.....	.....	14	29	.....	.....	.....	4	.....
8	17	6	.....	.....	.....	.....	30	.....	10	D	.....	4

Egg-Laying Records—*Hippodamia convergens* Guer.—(*Continued*)

Sacramento, 1913							Berkeley, 1914						
Date	1	2	3	4	5	6	Date	7	8	9	10	11
June 9	18	.....	.....	.....	21	.....	May 1	9	.....	.....	.....	D
10	19	16	.....	.....	.....	.....	2	.....	.....	.....	22	.....
11	27	14	.....	.....	.....	.....	3	.....	23	.....	.....	.....
12	22	7	.....	.....	.....	.....	4	.....	16	.....	.....	.....
13	26	13	.....	.....	.....	.....	5	D	8	.....	D	.....
14	12	22	.....	.....	.....	.....	6	.....	26	.....	.....	.....
15	7	8	.....	.....	.....	.....	7	.....	27	.....	.....	.....
16	6	.....	.....	.....	.....	.....	8	.....	5	.....	.....	.....
17	.....	21	.....	.....	.....	14	9	.....	11	.....	.....	.....
18	D	16	.....	.....	.....	.....	10	.....	.....	.....	.....	.....
19	.....	20	.....	.....	D	20	11	.....	14	.....	.....	.....
20	.....	6	.....	.....	.....	22	12	.....	12	.....	.....	.....
21	.....	5	.....	.....	.....	.....	13	.....	23	.....	.....	.....
22	.....	.....	.....	.....	.....	21	14	.....	.....	.....	.....	.....
23	.....	.....	.....	.....	.....	.....	15	.....	D	.....	.....	.....
24	.....	D	.....	.....	.....	9	16	.....	.....	.....	.....	.....
25	.....	.....	.....	.....	.....	D	17	.....	.....	.....	.....	.....
Total	425	466	94	141	115	234		371	609	176	280	326
Average	11.4	13.7	5.8	11.7	4.6	6.1		9.7	12.1	5.8	9.3	9.3

Life-History.—Under normal summer conditions in the Sacramento Valley the life-cycle of this species from egg to adult is accomplished within a period of approximately four weeks. The variation in this respect of eight individuals from the same parent extended from 27 to 34 days, averaging 28.75 days. This period was divided as follows: egg stage, 5 days; first larval, 3.9 days; second larval, 3.6 days; third larval, 2.3 days; fourth larval, 6.5 days; and the pupal stage, 7.5 days. The period of incubation of the eggs varied only a few hours among the eight individuals, while the variation in the first larval stage was from three to eight days, the second larval from two to four days, the third larval from two to three days, the fourth larval from six to eight days, and the pupal stage from seven to eight days. It will be seen that with few exceptions the period intervening between moults was quite constant and distinct for each stage.

Life-History—*Hippodamia convergens* Guer.

Sacramento, 1913

No.	Date eggs laid	Eggs hatched	Length of stage, days	1st moult	Length of stage, days	2d moult	Length of stage, days	3d moult	Length of stage, days	4th moult (pupation)	Length of stage, days	Emerged	Length of pupal stage, days	Total days of stages
1	5/18	5/23	5	5/26	3	5/30	4	6/1	2	6/7	6	6/14	7	27
2	5/18	5/23	5	5/26	3	5/30	4	6/1	2	6/8	7	6/16	8	29
3	5/18	5/23	5	5/26	3	5/30	4	6/1	2	6/7	6	6/15	8	28
4	5/18	5/23	5	5/26	3	5/30	4	6/1	2	6/7	6	6/14	7	27
5	5/18	5/23	5	5/31	8	6/2	2	6/5	3	6/13	8	6/21	8	34
6	5/18	5/23	5	5/26	3	5/30	4	6/1	2	6/7	6	6/14	7	27
7	5/18	5/23	5	5/26	3	5/30	4	6/1	2	6/8	7	6/15	8	29
8	5/18	5/23	5	5/28	5	5/31	3	6/3	3	6/9	6	6/16	7	29
Average			5		3.87		3.63		2.25		6.5		7.5	28.75

Feeding Habits.—The larvae immediately after hatching consume one or two aphids per day, but this number rapidly increases until near the end of the larval stage, when fifty or more may be eaten each day. There is no appreciable diminution in the number eaten upon days when moulting takes place, inasmuch as this requires only a short time, and the larvae immediately afterward resume feeding very actively. Throughout the experiment the hop aphis (*Phorodon humuli*) was used, with the exception of May 16–17, when the small rose aphis (*Macrosiphum rosae*) was substituted. The total number of aphids eaten during the stage ranged from 232 to 487, with an average of 349 for twelve specimens. The daily individual averages varied from 17.2 to 24.2 aphids per day, with a general average of 20.7 aphids. These data were compiled upon the basis of the number of days intervening between hatching and pupation, even though in nearly every case the larvae remained inactive and without food for one or more days preceding the casting of the fourth larval skin. All individuals were full size at the time of emergence with the exception of No. 6, which, strangely enough, consumed the largest number of aphids during the larval period.

Larval Feeding Records—*Hippodamia convergens* Guer.

Sacramento, 1913

Date		1	2	3	4	5	6	7	8	9	10	11	12
May	23	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	24	2	2	1	3	2	0	2	3	1	0	2	1
	25	3	2	2	4	6	2	6	4	3	3	5	3
	26	4*	7*	7*	8*	9*	4	6*	8	5*	4*	6	2*
	27	9	8	8	9	8	7	7	5*	6	7	6	5
	28	5	3	5	2	10	3	11	2	5	7	2*	8
	29	3	8	5	2	4	2	6	1	4	4	5	6
	30	10*	9*	7*	8*	8	3	9*	7*	6*	6*	8	14
	31	24	21	21	25	12*	12*	25	23	21	24	14*	27*
June	1	20*	24*	24*	19*	17	16	18*	21*	22*	14*	25	13
	2	45	17	33	41	35	24*	44	36	43	26	39	21
	3	44	48	40	50	26*	35	47	37	42	29	43*	32*
	4	33	59	46	52	58	46	31	28	24	47	40	37
	5	41	60	33	49	55	37*	51	36	53	52	54	41
	6	.....	54	.....	.....	51	31	.....	39	42	41	61	35
	7	P	.....	P	P	46	57	P	42	56	.....	53	.....
	8	.....	P	.....	.....	39	61	.....	48	37	P	.....	P
	9	.....	.....	.....	.....	.....	54	.....	57	41	.....	P	.....
	10	.....	.....	.....	.....	P	32	.....	17	27	.....	.....	.....
	11	.....	.....	.....	.....	.....	29	.....	13	.....	.....	.....	.....
	12	.....	.....	.....	.....	.....	32	.....	39	D	.....	.....	.....
	13	.....	.....	.....	.....	.....	P	.....	24	.....	.....	.....	.....
	14	E	.....	.....	E	.....	.....	E	D	.....	.....	.....	.....
	15	.....	.....	E	.....	.....	.....	.....	.....	.....	E	.....	E
	16	.....	E	.....	.....	.....	.....	.....	.....	.....	.....	E	.....
	17	.....	.....	.....	.....	E	.....	.....	.....	.....	.....	.....	.....
	18	.....	.....	.....	.....	.....	E	.....	.....	.....	.....	.....	.....
Total		243	322	232	272	386	487	263	490	438	264	363	245
Average		18.6	23.0	17.8	20.9	24.1	25.6	20.2	23.3	24.3	20.3	24.2	17.5

The adult feeding records were taken upon the basis of pairs from storage May 2, 1914, and were continued till the death of the individuals. In every case the death of the male, the date of which is indicated in the table by an asterisk, took place within two weeks after the beginning of the test, while the females lived considerably longer. For use as a basis of comparison the eight-day period from May 15 to May 23 will be taken, using specimens Nos. 1, 2, 4, 5, 6, and 7. The maximum number for the period was 515, the minimum 380, and the average 449 aphids. The daily averages ranged from 46.6 to 64.2, giving a general group average of 56.1 aphids per day.

Adult Feeding Records—*Hippodamia convergens* Guer.

Sacramento, 1913

Pairs of Adults from Cold Storage, May 2, 1913

Date	2	3	5	8	9	10	11
May 8	50	50	50	50	50	50	50
9	65	56	55	28	32	30	21
10	31	44	40	45	51	32	36
11	32	22	62	38	33	26	38
12	41	32	46	50	39	43	48
13	38	44	48	48	50	50*	49
14	54	52	60	58	60	35	57
15	40*	75*	75	65*	69*	47	75*
16	52	69	75	42	65	39	43
17	64	41	82	48	67	62	52
18	31	53	96	43	46	71	67
19	27	32	99	50	58	74	74
20	32	27	94	37	36	57	73
21	26	46	98	64	49	53	49
22	68	50	137	86	54	70	74
23	81	62	173	72	88	87	83
24	100	79	186	D	107	88	D
25	34	67	169	.....	77	64	.....
26	56	71	97	.....	58	19	.....
27	28	D	37	.....	42	26	.....
28	17	.....	85	.....	46	64	.....
29	66	.....	147	.....	69	86	.....
30	D	.....	186	.....	72	87	.....
31	.....	.....	203	.....	107	91	.....
June 1	.....	.....	183	.....	63	80	.....
2	.....	.....	D	.....	74	92	.....
3	.....	.....	.....	.....	80	79	.....
4	.....	.....	.....	.....	91	92	.....
5	.....	.....	.....	.....	78	96	.....
6	.....	.....	.....	.....	91	74	.....
7	.....	.....	.....	.....	89	67	.....
8	.....	.....	.....	.....	40	83	.....
9	.....	.....	.....	.....	92	97	.....
10	.....	.....	.....	.....	73	99	.....
11	.....	.....	.....	.....	86	86	.....
12	.....	.....	.....	.....	71	74	.....
13	.....	.....	.....	.....	106	92	.....
14	.....	.....	.....	.....	79	112	.....
15	.....	.....	.....	.....	66	88	.....
16	.....	.....	.....	.....	69	74	.....
17	.....	.....	.....	.....	73	97	.....
18	.....	.....	.....	.....	37	79	.....
19	.....	.....	.....	.....	D	86	.....
20	.....	.....	.....	.....	.....	D	.....
Total	1033	972	2583	824	2783	2998	889

Hippodamia ambigua Lec.

The same general considerations may be applied for this species as were given for *H. convergens.* The elytra, being red and devoid of marking, easily serve to distinguish this species. So far as known no detailed breeding has been carried on to determine the exact relationship of these two forms.

Oviposition.—Egg-laying records were secured for eight individuals, with results corresponding quite closely to those secured with *H. convergens.* The maximum number secured in one day was 24 and for the entire period 421, with a minimum of 199 and a general average of 312 eggs. The daily individual averages ranged from 6.5 to 8.4, with a general average of 6.3 eggs per day. The total length of the egg-laying period ranged from 25 to 59 days, averaging 48.1. The proportion of days upon which eggs were deposited was 61.4 per cent, the variation being from 48.0 to 25.0 per cent.

Egg-Laying Records—*Hippodamia ambigua* Lec.

Berkeley, 1914

Date	1	2	3	4	5	6	7	8
March 25	.....	10	.....	.....	.....	.....	.....	.....
26	.....	6	.....	.....	.....	.....	.....	.....
27	3	.....	.....	3	.....	10	.....	.....
28	.....	8	.....	11	.....	.....	.....	4
29	7	14	.....	2	.....	14	.....	.....
30	.....	5	9	.....	5	12	.....	5
31	.....	11	.....	16	.....	.....	7	11
April 1	6	3	13	5	14	6	.....	18
2	9	.....	6	.....	8	18	13	.....
3	.....	12	.....	11	12	.....	.....	21
4	11	5	4	13	.....	4	5	.....
5	13	21	.....	8	15	16	9	15
6	.....	.....	12	21	18	12	.....	20
7	5	16	8	16	.....	19	11	18
8	17	.....	.....	3	22	9	.....	.....
9	12	18	13	.....	16	8	21	7
10	16	5	.....	12	4	11	16	14
11	8	14	5	.....	.....	4	12	.....
12	22	10	.....	24	12	16	.....	19
13	.....	12	.....	11	.....	.....	14	.....
14	5	3	9	.....	13	6	.....	26
15	11	8	.....	21	.....	.....	.....	.....
16	14	.....	16	12	.....	9	13	.....
17	10	7	22	.....	19	8	.....	.....

Egg-Laying Records—*Hippodamia ambigua* Lec.—(*Continued*)

Berkeley, 1914

Date		1	2	3	4	5	6	7	8
April	18	4	13	8	9	22	14	.....	13
	19	.....	6	.....	6	9	23	6	.....
	20	13	.....	14	.....	14	18	.....	.....
	21	.....	5	6	13	.....	12	18	.....
	22	.....	.....	11	5	8	.....	22	8
	23	8	.....	.....	.....	17	15	9	.....
	24	6	16	9	20	.....	8	15	D
	25	.....	.....	16	.....	6	.....	.....	.....
	26	11	.....	13	.....	.....	9	12	.....
	27	14	8	20	16	.....	.....	20	.....
	28	24	.....	3	5	D	12	16	.....
	29	16	.....	.....	19	.....	3	11	.....
	30	10	.....	2	.....	.....	14	4	.....
May	1	.....	D	.....	13	.....	.....	.....	.....
	2	15	.....	6	12	.....	8	.....	.....
	3	9	.....	8	6	.....	.....	7	.....
	4	8	.....	.....	19	.....	10	.....	.....
	5	.....	.....	14	.....	.....	.....	13	.....
	6	.....	.....	.....	4	.....	17	9	.....
	7	3	.....	11	.....	.....	.....	15	.....
	8	.....	.....	9	8	.....	19	.....	.....
	9	1	.....	21	.....	.....	20	20	.....
	10	.....	.....	15	.....	.....	16	.....	.....
	11	D	.....	.....	12	.....	11	.....	.....
	12	.....	.....	13	.....	.....	.....	21	.....
	13	.....	.....	.....	.....	.....	5	.....	.....
	14	.....	.....	6	D	.....	.....	9	.....
	15	.....	.....	.....	.....	.....	.....	8	.....
	16	.....	.....	3	.....	.....	.....	.....	.....
	17	.....	.....	.....	.....	.....	D	3	.....
	18	.....	.....	.....	.....	.....	.....	12	.....
	19	.....	.....	D	.....	.....	.....	9	.....
	20	.....	.....	.....	.....	.....	.....	18	.....
	21	.....	.....	.....	.....	.....	.....	4	.....
	22	.....	.....	.....	.....	.....	.....	0	.....
	23	.....	.....	.....	.....	.....	.....	0	.....
	24	.....	.....	.....	.....	.....	.....	10	.....
	25	.....	.....	.....	.....	.....	.....	3	.....
	26	.....	.....	.....	.....	.....	.....	5	.....
	27	.....	.....	.....	.....	.....	.....	0	.....
	28	.....	.....	.....	.....	.....	.....	1	.....
	29	.....	.....	.....	.....	.....	.....	D	.....
Total		311	236	325	356	234	416	421	199
Average		6.7	6.3	6.4	7.4	8.0	8.1	7.1	7.3

Life-History.—The life-cycle of *Hippodamia ambigua* from egg to adult at Berkeley, California, during April and May was 33.2 days. The various stages required the following periods of time: egg stage, 6 days; first larval, 3.8 days; second larval, 4.7 days; third larval, 3.6 days; fourth larval, 7.3 days; and the pupal stage, 8.0 days. The variations within these periods were: first larval, three to five days; second larval, four to five days; third larval, three to four days; fourth larval, six to nine days, and in the pupal state, seven to nine days.

Life-History—*Hippodamia ambigua* Lec.
Berkeley, 1913

No.	Date eggs laid	Eggs hatched	Length of stage, days	1st moult	Length of stage, days	2d moult	Length of stage, days	3d moult	Length of stage, days	4th moult (pupation)	Length of stage, days	Emerged	Length of pupal stage, days	Total days of stages
1	4/2	4/8	6	4/11	3	4/16	5	4/19	3	4/26	7	5/4	8	32
2	4/2	4/8	6	4/13	5	4/17	4	4/20	3	4/28	8	4/7	9	35
3	4/2	4/8	6	4/11	3	4/16	5	4/20	4	4/27	7	5/5	8	33
4	4/2	4/8	6	4/12	4	4/18	6	4/22	4	4/29	7	5/6	7	34
5	4/2	4/8	6	4/11	3	4/15	4	4/18	3	4/26	8	5/3	7	31
6	4/2	4/8	6	4/12	4	4/17	5	4/21	4	4/27	6	5/5	8	33
7	4/2	4/8	6	4/11	3	4/15	4	4/19	4	4/25	6	5/3	8	31
8	4/2	4/8	6	4/13	5	4/18	5	4/21	3	4/29	8	5/7	8	35
9	4/2	4/8	6	4/12	4	4/16	4	4/20	4	4/29	9	5/7	8	33
10	4/2	4/8	6	4/12	4	4/17	5	4/21	4	4/28	7	5/7	9	35
Average			6		3.8		4.7		3.6		7.3		8	33.2

Feeding Habits.—The eight individuals used in the larval feeding experiment were the same as those from which the life-history records were secured. During the period extending over approximately 28 days a maximum of 396 and a minimum of 269 aphids were eaten, giving an average of 312 for the period; the daily average extended from 10.3 to 14.3, with a general average of 11.4 aphids per day. Of particular interest is the comparatively low number consumed during the first eight or nine days, and even after this the number was very low, 37 aphids being the largest number eaten by an individual in one day. The temperature during the early part of the test was

rather low, the daily maximum being from 65° to 75° Fahrenheit. For feeding purposes rather large rose aphids were used throughout, these being somewhat larger than the hop aphid used in the feeding tests at Sacramento, California. In the adult feeding records for ten individuals the period total varied from 370 to 429, with an average of 397 aphids. This represents a daily consumption of 24 to 28 aphids, with a general average of 26.5 per day. The largest number eaten by an individual in one day was 42.

Larval Feeding Records—*Hippodamia ambigua* Lec.

Berkeley, 1913

Date		1	2	3	4	5	6	7	8
April	8	H	H	H	H	H	H	H	H
	9	1	2	0	0	1	3	2	1
	10	2	1	1	3	3	2	1	0
	11	2	2	0	2	2	3	2	2
	12	3	0	2	3	4	3	5	6
	13	4	3	4	6	2	6	2	5
	14	5	5	6	3	3	5	4	9
	15	7	7	9	5	6	9	9	8
	16	6	8	12	9	8	6	13	10
	17	5	11	10	8	15	6	8	6
	18	12	10	14	10	10	9	10	7
	19	8	12	16	8	9	13	11	13
	20	13	11	9	13	13	15	15	10
	21	10	14	7	16	12	14	8	18
	22	16	21	15	12	17	12	16	5
	23	15	15	22	10	15	19	14	8
	24	12	12	12	15	8	15	13	12
	25	5	26	10	18	11	10	19	16
	26	11	17	13	24	16	8	12	10
	27	13	15	16	27	15	14	7	13
	28	18	23	19	12	26	17	15	9
	29	15	20	15	17	20	23	18	15
	30	26	30	27	15	18	26	23	19
May	1	32	16	15	28	22	18	16	24
	2	30	12	18	22	27	24	27	21
	3	.....	37	24	15	P	16	P	17
	4	P	28	16	18	.....	21	.....	19
	5	.....	24	P	5	.....	P	.....	27
	6	.....	10	.....	P	.....	.....	.....	10
	7	.....	P	.....	.....	.....	.....	.....	P
Total		271	392	312	324	283	317	270	320
Average		11.2	14.0	12.2	12.4	11.3	12.1	11.2	11.4

Adult Feeding Records—*Hippodamia ambigua* Lec.

Berkeley, 1914

Date	1	2	3	4	5	6	7	8	9	10
Aug. 25	19	26	23	28	16	22	30	19	21	25
26	28	29	27	23	31	27	29	22	26	27
27	24	20	18	29	24	31	33	18	23	20
28	35	27	33	26	29	20	37	26	19	23
29	27	29	20	37	21	26	24	29	24	18
30	19	31	22	33	26	29	20	24	30	27
31	23	26	19	29	34	24	26	18	21	24
Sept. 1	26	38	33	42	37	18	23	20	27	33
2	21	25	37	28	23	30	19	36	29	17
3	39	27	24	16	29	27	27	23	26	28
4	30	17	26	33	18	26	35	15	30	29
5	22	32	22	24	20	31	29	27	16	33
6	28	37	34	28	31	18	27	35	28	39
7	31	25	31	22	26	19	32	32	21	27
8	19	28	24	26	34	23	38	26	29	34
Total	391	417	393	424	399	371	429	370	370	404
Average	26.1	27.8	26.2	28.3	26.6	24.7	28.6	24.7	24.7	26.9

Olla abdominalis Say

This species is one of the most important aphid eaters in California, and is especially abundant in the southern part of the state. Feeding has been observed upon the hop, rose, melon, and cabbage aphids, but a very decided preference is usually shown for the walnut aphis (*Chromaphis juglandicola*). The adults hibernate singly under fragments of bark, dead leaves, etc., and emerge in the spring somewhat later than *Hippodamia convergens*.

Oviposition.—The time intervening between emergence and mating was found to average 1.7 days, with a range of one to three days. From mating to egg-laying, the time varied from seven to ten days, with an average of 8.6 days for the nine individuals under observation.

The period of oviposition ranged from 19 to 47 days, with an average of 34.7 days. The proportion of days upon which oviposition occurred was 73.8 per cent as a maximum and 66 per cent as a minimum, and averaged 70.3 per cent. The maximum number of eggs deposited in one day was 25 and for the full period of oviposition 298, with averages of 6.3 and 294 respect-

ively for the nine individuals. The minimum number deposited by one female was 130 eggs.

Egg-Laying Records—*Olla abdominalis* Say

Berkeley, 1914

Date		1	2	3	4	5	6	7	8	9
March	24	.....	.....	.....	.....	E	.....	.....	E	.....
	25	.....	E	.....	.....	.....	E	E	.....	.....
	26	.....	M	E	.....	M	.....	.....	.....	.....
	27	E	.....	.....	E	.....	M	M	M	E
	28	M	.....	M	M	.....	.....	.....	.....	M
	29	.....	.....	.....	.....	.....	.....	.....	.....	.....
	30	.....	.....	.....	.....	.....	.....	.....	.....	.....
	31	.....	.....	.....	.....	.....	.....	.....	.....	.....
April	1	.....	.....	.....	.....	.....	.....	.....	.....	.....
	2	.....	.....	.....	.....	.....	.....	.....	.....	.....
	3	.....	.....	.....	.....	.....	.....	.....	.....	.....
	4	.....	4	.....	.....	.....	.....	.....	.....	.....
	5	.....	2	.....	6	.....	2	.....	.....	.....
	6	4	14	.....	7	5	4	.....	3	10
	7	5	11	4	9	9	.....	12	5	5
	8	11	.....	2	5	.....	.....	.....	8	.....
	9	16	16	5	.....	2	.....	16	.....	11
	10	.....	5	9	11	7	6	10	17	4
	11	14	13	13	7	.....	10	4	10	16
	12	12	10	11	14	14	11	.....	9	10
	13	7	8	.....	.....	12	7	13	.....	6
	14	6	.....	6	3	8	16	5	12	.....
	15	10	4	.....	12	13	.....	.....	4	5
	16	.....	13	15	.....	9	14	8	6	9
	17	8	6	14	16	5	12	16	.....	.....
	18	13	.....	5	.....	10	.....	7	8	14
	19	5	12	7	13	.....	25	11	.....	6
	20	12	.....	15	7	6	18	14	11	5
	21	6	15	.....	.....	15	5	.....	12	16
	22	.....	19	.....	5	17	11	9	5	12
	23	11	7	8	10	.....	.....	.....	.....	.....
	24	.....	5	11	16	21	2	3	14	8
	25	.....	13	.....	8	14	.....	.....	7	.....
	26	2	4	4	3	.....	3	2	.....	15
	27	17	.....	13	4	13	.....	D	6	7
	28	.....	9	10	.....	12	16	.....	18	6
	29	18	.....	6	7	5	20	.....	15	9
	30	12	11	17	6	.....	15	.....	8	.....
May	1	9	15	.....	13	8	5	.....	12	8
	2	14	12	4	.....	16	9	.....	.....	.....
	3	.....	3	.....	10	.....	.....	.....	4	5

Egg-Laying Records—*Olla abdominalis* Say—(*Continued*)

Berkeley, 1914

Date	1	2	3	4	5	6	7	8	9
4	6	8	5	19	4	14	.....	.....	10
5	.....	.....	3	15	.....	12	.....	3	13
6	.....	2	.....	4	D	3	.....	.....	.....
7	D	14	1	6	.....	.....	.....	7	9
8	.....	.....	.....	.....	.....	6	.....	9	6
9	.....	5	D	9	.....	4	.....	11	17
10	.....	11	.....	.....	.....	.....	.....	.....	.....
11	.....	.....	.....	8	.....	2	.....	10	8
12	.....	6	.....	.....	.....	.....	.....	.....	.....
13	.....	.....	.....	11	.....	11	.....	2	4
14	.....	8	.....	D	.....	5	.....	.....	.....
15	.....	3	.....	.....	.....	.....	.....	D	2
16	.....	.....	.....	.....	.....	7	.....	.....	.....
17	.....	D	.....	.....	.....	16	.....	.....	.....
18	.....	.....	.....	.....	.....	.....	.....	.....	D
19	.....	.....	.....	.....	.....	4	.....	.....	.....
20	.....	.....	.....	.....	.....	.....	.....	.....	.....
21	.....	.....	.....	.....	.....	2	.....	.....	.....
22	.....	.....	.....	.....	.....	1	.....	.....	.....
23	.....	.....	.....	.....	.....	.....	.....	.....	.....
24	.....	.....	.....	.....	.....	D	.....	.....	.....
Total	218	288	188	264	225	298	130	236	256
Average	7.0	6.6	5.8	6.7	7.5	6.0	6.5	6.0	6.0

Life-History.—Eight of the twelve eggs used in the experiment hatched within four days, while the remaining four required five days, even though the temperature conditions were practically identical throughout the ten days during which the three clusters of eggs were incubating. The first larval period required 3.3 days, the second 2.3 days; the third 2.8 days; the fourth 4.7 days; and the pupal stage 3.5 days; giving a total of 21 days from egg to adult. The variations in time within the periods were, first larval, three to four days; second larval, two to four days; third, two to three days; fourth, four to six days; and in the pupal period, three to four days. The range in the total life-cycle was from twenty to twenty-three days, showing a rather unusual uniformity.

Life-History—*Olla abdominalis* Say

Sacramento, 1913

No.	Date eggs laid	Eggs hatched	Length of stage, days	1st moult	Length of stage, days	2d moult	Length of stage, days	3d moult	Length of stage, days	4th moult (pupation)	Length of stage, days	Emerged	Length of pupal stage, days	Total days of stages
1	6/18	6/22	4	6/25	3	6/27	2	6/30	3	7/6	4	7/10	4	20
2	6/18	6/22	4	6/26	4	6/28	2	7/1	3	7/6	5	7/9	3	21
3	6/18	6/22	4	6/25	3	6/29	4	7/1	3	7/6	5	7/9	3	22
4	6/18	6/22	4	6/26	4	6/29	3	7/1	3	7/5	4	7/8	3	21
5	6/18	6/22	4	6/26	4	6/29	3	7/1	3	7/6	5	7/10	4	23
6	6/18	6/22	4	6/26	4	6/28	2	6/30	2	7/6	6	7/9	3	21
7	6/25	6/30	5	7/3	3	7/5	2	7/8	3	7/12	4	7/16	4	21
8	6/25	6/30	5	7/3	3	7/5	2	7/8	3	7/12	4	7/16	4	21
9	6/25	6/30	5	7/3	3	7/5	2	7/8	3	7/12	4	7/16	4	21
10	6/25	6/30	5	7/3	3	7/5	2	7/7	2	7/12	5	7/16	4	21
11	6/24	6/28	4	7/1	3	7/3	2	7/6	3	7/11	5	7/14	3	20
12	6/24	6/28	4	7/1	3	7/3	2	7/6	3	7/11	5	7/14	3	20
Average			4.3		3.3		2.3		2.8		4.7		3.5	21.

Feeding Records.—For the larval records three distinct series of experiments comprising thirty individuals were carried on, and of these fourteen finally reached maturity. The range in total number of aphids eaten extended from 196 to 266, with an average of 240, which, when reduced to a daily basis, represents 19.8 aphids per day for the larval period of approximately 17 days. A marked increase in the feeding was observed immediately after the second moult.

Larval Feeding Records—*Olla abdominalis* Say

Sacramento, 1913

Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14
June 22	H	H	H	H	H	H	H	H	.....	.....	.....	.....	.....	.....
23	2	1	1	2	0	1	1	3	.....	.....	.....	.....	.....	.....
24	1	3	1	3	2	4	2	3	.....	.....	.....	.....	.....	.....
25	7*	4	3	5*	6	5	2	4	.....	.....	.....	.....	.....	.....
26	4	9*	8*	8	5*	9*	6*	7*	.....	.....	.....	.....	.....	.....
27	12*	6	14	17*	11	12	7*	16	.....	.....	.....	.....	.....	.....
28	17	12	11	16	19	21	15*	13	H	H	.....	.....	.....	.....
29	14	9*	17*	21	23*	19*	22	20*	0	1	.....	.....	.....	.....
30	23*	18	18	26	16	20	20*	29	3	2	H	H	H	H

Larval Feeding Records—*Olla abdominalis* Say—(*Continued*)

Sacramento, 1913

Date		1	2	3	4	5	6	7	8	9	10	11	12	13	14
July	1	27	24*	32*	13	21*	32*	30	36*	4*	6*	3	2	3	1
	2	19	36	28	33*	37	28	17	19	9	8	4	5	4	5
	3	41	31	39	47	26	37	31	25	6*	13*	7*	7*	5*	3*
	4	46	43	47	43	39	41	46	39	14	20	12	9	11	8
	5	37	0	21	29	P	30	39	42	27	23*	21*	18	21*	16*
	6	P	P	P	P	.....	P	P	P	36*	18	29	23*	16	13
	7	.....	.....	.....	.....	.....	.....	.....	.....	29	31	17	36	29	21*
	8	.....	.....	.....	.....	E	.....	.....	.....	42	37	38*	28*	23*	32
	9	.....	E	E	.....	.....	.....	E	.....	49	40	47	39	38	43
	10	E	.....	.....	E	.....	E	.....	E	35	32	39	46	41	52
	11	.....	.....	.....	.....	.....	.....	.....	.....	P	P	41	33	49	37
	12	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	P	P	P	P
	13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	14	.....	.....	.....	.....	.....	.....	.....	.....	E	E	.....	.....	.....	.....
	15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	16	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	E	E	E	E
Total		250	196	240	263	205	259	238	256	254	231	258	246	240	231
Average		19.2	15.0	18.6	20.2	17.0	19.9	18.3	19.6	21.1	19.2	23.4	22.3	21.8	21.0

In the adult feeding records, complete data were secured for nine individuals, six of which were females. For the entire fifteen-day period the number of aphids consumed daily ranged from 16 to 47, with an average of 30.4 aphids per day. The period totals varied from 407 to 534, averaging 457 aphids for the entire series.

Medium-sized rose aphids (*Macrosiphum rosae*) were used for feeding purposes throughout this experiment.

Adult Feeding Records—*Olla abdominalis* Say

Uplands, 1914

Date		1	2	3	4	5	6	7	8	9
June	8	26	37	22	40	28	19	30	25	32
	9	18	25	28	35	23	27	21	28	26
	10	35	27	25	32	29	36	27	33	41
	11	27	40	36	18	37	28	34	31	26
	12	36	36	45	20	26	22	19	26	19
	13	32	29	32	26	33	29	15	42	22
	14	41	27	21	32	46	18	26	37	40
	15	28	16	26	37	19	37	29	53	35

Adult Feeding Records—*Olla abdominalis* Say—(*Continued*)

Uplands, 1914

Date		1	2	3	4	5	6	7	8	9
June	16	32	25	40	24	17	26	40	60	43
	17	21	38	29	29	28	33	28	27	37
	18	37	47	32	38	26	38	26	19	22
	19	16	28	21	32	29	17	34	38	29
	20	35	33	37	41	37	20	37	35	43
	21	39	30	39	27	34	29	23	41	17
	22	41	34	28	35	22	33	18	39	28
Total		464	472	461	466	434	412	407	534	460
Average		30.9	31.4	30.7	31.0	28.9	27.4	27.0	35.6	30.6

Olla oculata Fabr.

This species is found generally distributed throughout the state and is particularly abundant in the southern section. Its constant association with *O. abdominalis* gives considerable strength to the belief that it is not a true species, but merely a varietal form of *O. abdominalis* Say. Other notes given in reference to *O. abdominalis* may be considered as applying to this form as well. A rather curious circumstance is that in a number of individuals of this species, at the time of emergence from the pupal skins, the elytra, which have a black ground color with an irregular dark red spot near the center, show faintly the markings of *O. abdominalis*, the ground-color of which is gray, with from six to nine small black spots on each wing-cover. These, however, are soon obscured by the rapidly developing black ground-color as it eventually exists.

Oviposition.—Complete records for the entire period of egg-laying were secured from nine individuals. The time from mating to oviposition varied from eight to thirteen days and averaged 10.7 days. The number of eggs deposited averaged 347, the greatest number secured from any species. The maximum number was 489 and the minimum 171 eggs. The highest daily record was 22, and the average for all individuals for the entire period was 9.8 eggs per day.

The period of oviposition in the nine females under observation ranged from 17 to 46 days, with an average of 35. During these periods the proportion of days upon which eggs were de-

posited varied from 84.3 to 95.5 per cent, averaging 89.3 per cent for all individuals, which may be said to be a decidedly unusual condition.

Egg-Laying Records—*Olla oculata* Fabr.

Riverside, 1914

Date		1	2	3	4	5	6	7	8	9
May	26	M	.....	M	M	.....	M	.....	M	M
	27	.....	M	.....	.....	.....	.....	M	.....	.....
	28	.....	.....	.....	.....	M	.....	.....	.....	.....
	29	.....	.....	.....	.....	.....	.....	.....	.....	.....
	30	.....	.....	.....	.....	.....	.....	.....	.....	.....
	31	.....	.....	.....	.....	.....	.....	.....	.....	.....
June	1	.....	.....	.....	.....	.....	.....	.....	.....	.....
	2	.....	.....	.....	.....	.....	.....	.....	.....	.....
	3	.....	.....	.....	.....	.....	.....	.....	.....	.....
	4	.....	.....	.....	8	.....	.....	.....	.....	.....
	5	5	.....	.....	7	.....	.....	.....	.....	10
	6	12	.....	.....	5	.....	11	3	.....	8
	7	7	.....	.....	3	.....	13	2	7	14
	8	6	.....	2	12	5	5	7	2	5
	9	14	.....	11	6	3	12	5	0	11
	10	21	13	16	8	7	9	14	10	16
	11	17	8	14	14	6	10	9	18	7
	12	8	7	10	5	4	13	.....	5	12
	13	14	16	13	13	12	11	.....	10	6
	14	.....	5	9	21	6	.....	6	9	17
	15	19	20	7	.....	21	3	5	8	9
	16	12	6	12	19	14	9	14	17	21
	17	11	14	18	13	11	20	12	5	13
	18	17	8	11	11	8	11	20	11	17
	19	20	5	22	21	.....	16	17	9	10
	20	7	2	6	19	15	19	13	14	16
	21	6	12	10	6	9	12	11	8	12
	22	.....	7	18	5	13	8	14	16	5
	23	12	12	16	9	17	5	6	22	.....
	24	13	21	15	20	6	11	8	D	14
	25	5	17	9	12	8	14	9	.....	22
	26	15	14	3	14	12	7	4	.....	6
	27	.....	.....	.....	.....	.....	.....	.....	.....	.....
	28	8	12	.....	8	16	10	8	.....	9
	29	12	13	23	.....	19	14	13	.....	13
	30	13	21	17	4	13	12	5	.....	17
July	1	10	11	14	9	5	11	16	.....	12
	2	18	6	18	3	20	17	8	.....	14
	3	5	8	10	1	14	19	12	.....	22
	4	11	20	14	.....	8	13	14	.....	16

Egg-Laying Records—*Olla oculata* Fabr.—(*Continued*)

Riverside, 1914

Date	1	2	3	4	5	6	7	8	9
5	7	18	20	D	.....	8	12	.....	2
6	8	15	1	.....	13	22	19	.....	12
7	2	16	3	.....	19	12	10	.....	6
8	.....	9	12	.....	7	19	5	.....	8
9	D	4	7	.....	11	13	.....	.....	5
10	.....	.....	13	.....	12	17	3	.....	3
11	.....	3	5	.....	5	9	2	.....	9
12	.....	.....	8	.....	3	18	7	.....	.....
13	.....	D	16	.....	.....	15	.....	.....	1
14	.....	.....	20	.....	D	12	D	.....	3
15	.....	.....	12	.....	.....	.....	.....	.....	2
16	.....	.....	7	.....	.....	11	.....	.....	1
17	.....	.....	6	.....	.....	5	.....	.....	D
18	.....	.....	8	.....	.....	3	.....	.....	.....
19	.....	.....	4	.....	.....	2	.....	.....	.....
20	.....	.....	D	.....	.....	8	.....	.....	.....
21	.....	.....	.....	.....	.....	.....	.....	.....	.....
22	.....	.....	.....	.....	.....	D	.....	.....	.....
Total	335	343	460	276	342	489	313	171	406
Average	9.8	10.3	10.9	8.9	9.5	10.6	8.2	10.0	9.6

Life-History—*Olla oculata* Fabr.

Riverside, 1914

No.	Date eggs laid	Eggs hatched	Length of stage, days	1st moult	Length of stage, days	2d moult	Length of stage, days	3d moult	Length of stage, days	4th moult (pupation)	Length of stage, days	Emerged	Length of pupal stage, days	Total days of stages
1	5/26	6/1	5	6/5	4	6/9	4	6/13	4	6/20	7	6/25	5	29
2	5/26	6/1	5	6/7	6	6/10	3	6/14	4	6/21	7	6/26	5	30
3	5/26	6/1	5	6/6	5	6/10	4	6/14	4	6/21	7	6/26	5	30
4	5/26	6/1	5	6/5	4	6/9	4	6/13	4	6/20	7	6/25	5	29
5	5/26	6/1	5	6/5	4	6/11	6	6/16	5	6/22	6	6/27	6	31
6	5/26	6/1	5	6/5	4	6/10	5	6/14	4	6/21	7	6/27	5	31
7	5/26	6/1	5	6/6	5	6/11	5	6/14	3	6/21	7	6/26	5	30
8	5/26	6/1	5	6/5	4	6/9	4	6/13	4	6/21	8	6/26	5	30
9	5/26	6/1	5	6/7	6	6/11	4	6/16	5	6/23	7	6/28	5	32
10	5/26	6/1	5	6/6	5	6/10	4	6/14	4	6/20	6	6/25	5	29
11	5/26	6/1	5	6/5	4	6/9	4	6/14	5	6/22	8	6/27	5	31
Average			5.0		4.6		4.3		4.2		7.0		5.1	30.2

Life-History.—All individuals used in the life-history experiments were secured from a single cluster of eggs deposited May 26. These hatched five days later, and reached the adult stage in approximately twenty-six days, the larval and pupal stages requiring twenty-one and five days, respectively. The first larval stage required from four to six days, the second three to six days, the third three to five days, the fourth six to eight days, and the pupal period a constant five days with a single exception, which required six days. No striking deviations from the normal can be noted here, and the range of from twenty-nine to thirty-two days in the total period represents only a comparatively slight variation for a life-cycle of that length.

Feeding Records.—The larval feeding records were secured from ten individuals fed throughout the period upon medium-sized rose aphids. The number eaten varied from 299 to 349 for the period of approximately 25 days, with an average of 326 aphids. The daily average for all specimens was 17.2, representing a range of from 15.3 to 19.3 aphids per day. Feeding was continuous up to the day of pupation.

The adult individual records for the fifteen-day period varied from 589 to 672, and averaged 624, which is very uniform as compared with the variation secured in experiments with other species. The daily records as derived from this ranged from 39.2 to 44.8, with an average of 41.6 aphids per day. The largest number eaten in one day by a single adult was 77 aphids.

Medium-sized rose aphids (*Macrosiphum rosae*) were used exclusively for feeding purposes in this experiment.

Larval Feeding Records—*Olla oculata* Fabr.

Riverside, 1914

Date	1	2	3	4	5	6	7	8	9	10
June 1	H	H	H	H	H	H	H	H	H	H
2	2	1	1	1	1	3	1	2	1	0
3	2	2	1	1	2	1	1	1	2	2
4	4	5	3	6	5	4	4	3	5	6
5	4	6	5	7	6	6	3	5	4	7
6	9	7	5	13	10	8	11	7	6	8
7	13	10	12	14	12	10	8	13	9	12
8	17	16	8	12	10	14	11	19	15	5
9	19	17	14	20	15	9	16	23	18	13
10	16	15	17	14	21	19	17	15	22	18

Larval Feeding Records—*Olla oculata* Fabr.—(*Continued*)

Riverside, 1914

Date	1	2	3	4	5	6	7	8	9	10
June 11	23	18	22	16	24	14	25	21	19	22
12	27	25	19	28	25	18	23	27	26	20
13	21	20	23	18	22	23	31	22	19	25
14	31	24	26	19	23	27	18	26	22	30
15	33	24	29	26	30	16	20	22	12	19
16	21	28	19	22	35	20	25	23	18	24
17	37	24	28	24	40	29	18	31	29	23
18	29	28	32	27	31	37	25	33	19	29
19	7	33	41	30	37	19	27	30	22	36
20	P	35	32	12	P	26	31	18	12	P
21	.....	P	P	P	.....	30	P	P	29	.....
22	.....	.....	.....	.....	.....	P	.....	.....	14	.....
23	.....	.....	.....	.....	.....	.....	.....	.....	P	.....
24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
25	E	.....	.....	E	E	.....	.....	.....	.....	.....
27	.....	E	E	.....	.....	.....	.....	E	.....	.....
28	.....	.....	.....	.....	.....	E	E	.....	E	E
Total	315	338	338	310	349	333	315	341	323	299
Average	17.5	17.7	17.7	16.3	19.3	16.6	16.5	17.9	15.3	16.6

Adult Feeding Records—*Olla oculata* Fabr.

Riverside, 1914

Date	1	2	3	4	5	6	7	8	9	10
May 26	35	41	28	33	26	44	27	31	38	47
27	29	24	36	28	29	23	36	29	32	39
28	42	37	45	26	37	32	41	40	35	22
29	63	54	52	46	61	49	53	37	48	39
30	27	31	33	40	28	22	29	30	34	27
31	41	32	39	36	43	27	36	29	28	37
June 1	52	63	70	55	61	48	59	43	60	52
2	57	48	51	50	39	44	52	37	42	38
3	43	37	21	39	28	36	35	43	27	29
4	31	23	29	26	35	29	40	24	32	41
5	22	27	26	34	21	32	37	31	26	22
6	49	52	37	41	39	40	32	46	41	37
7	62	50	46	61	47	54	56	49	60	48
8	65	73	59	81	77	84	66	59	63	69
9	54	43	40	52	36	57	49	61	44	53
Total	672	635	612	648	607	621	648	589	610	600
Average	44.8	42.3	40.8	43.2	40.4	41.4	43.2	39.2	40.6	40.

Adalia bipunctata Linn.

This species is very abundant in the San Francisco Bay Region, and is found in comparatively small numbers in other parts of the state, though none were found by the writer in the Sacramento Valley. During the winter the adults hibernate in sheltered and protected places, as many as fifty having been found in one colony under a loose strip of eucalyptus bark, this being a location much favored by this particular species. All of the common aphis species are preyed upon by this beetle and, so far as observed, no particular one can be termed its favorite food.

Oviposition.—The period intervening between emergence and mating was found in ten individuals to vary from one to two days, with an average of 1.6 days, while the time from mating to egg-laying ranged from eight to eleven days, averaging 9.6 days. The complete period of oviposition required from 20 to 39 days, and during this period the proportion of days upon which eggs were actually deposited varied from 60.0 to 76.3 per cent. The averages were 28.2 days and 69.4 per cent, respectively. The maximum number of eggs deposited in one day was 23, while the average daily production by the ten females was 6.7 eggs per day. For the entire adult period, the variation in number extended from 94 to 269, with an average of 190 eggs for each individual.

Egg-Laying Records—*Adalia bipunctata* Linn.

Berkeley, 1914

Date	1	2	3	4	5	6	7	8	9	10
April 1	E	.....	.....	E	.....	.....	E	E	E	.....
2	.....	E	E	M	.....	E	.....	.....	.....	.....
3	M	M	.....	.....	E	M	M	M	M	E
4	.....	.....	M	.....	.....	.....	.....	.....	.....	M
5	.....	.....	.....	.....	M	.....	.....	.....	.....	.....
6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
11	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
12	4	.....	.....	.....	.....	.....	7	.....	.....	.....
13	3	.....	3	.....	.....	.....	2	.....	2	.....

Egg-Laying Records—*Adalia bipunctata* Linn.—(*Continued*)

Berkeley, 1914

Date	1	2	3	4	5	6	7	8	9	10
April 14	.....	7	.....	5	6	.....	12	.....	.....	.....
15	6	9	8	.....	11	1	.....	4	3	.....
16	12	.....	11	4	9	3	8	6	5	9
17	8	16	.....	13	12	.....	5	11	.....	7
18	.....	12	14	6	.....	14	.....	7	9	11
19	9	.....	17	9	8	12	9	.....	12	4
20	14	18	18	.....	7	10	.....	13	8	7
21	7	.....	21	12	.....	6	14	8	.....	9
22	12	13	.....	11	5	.....	.....	.....	13	10
23	5	.....	6	11	.....	21	8	4	7	.....
24	.....	9	12	.....	15	8	16	20	.....	18
25	18	14	8	23	9	13	.....	7	12	15
26	16	.....	6	12	.....	5	14	11	6	.....
27	4	16	3	15	4	1	.....	3	9	12
28	.....	8	14	.....	.....	17	5	.....	17	.....
29	9	20	.....	8	3	6	9	12	.....	13
30	13	.....	7	.....	.....	3	3	.....	11	5
May 1	7	12	3	16	.....	.....	.....	18	12	10
2	6	.....	2	.....	5	14	.....	6	4	.....
3	.....	.....	.....	12	.....	9	7	.....	.....	13
4	12	22	D	8	D	.....	10	19	2	8
5	.....	.....	.....	4	.....	15	.....	.....	7	.....
6	9	16	.....	D	.....	3	4	8	15	.....
7	13	7	.....	.....	.....	8	1	12	.....	22
8	12	.....	.....	.....	.....	6	D	.....	10	6
9	.....	15	.....	.....	.....	.....	.....	.....	2	.....
10	5	.....	.....	.....	.....	11	.....	5	.....	.....
11	8	6	.....	.....	.....	4	.....	.....	12	3
12	.....	12	.....	.....	.....	.....	.....	D	6	1
13	14	.....	.....	.....	.....	9	.....	.....	14	D
14	9	5	.....	.....	.....	8	.....	.....	5	.....
15	13	.....	.....	.....	.....	.....	.....	.....	.....	.....
16	.....	7	.....	.....	.....	14	.....	.....	6	.....
17	6	.....	.....	.....	.....	20	.....	.....	.....	.....
18	.....	D	.....	.....	.....	6	.....	.....	D	.....
19	12	.....	.....	.....	.....	.....	.....	.....	.....	.....
20	.....	.....	.....	.....	.....	14	.....	.....	.....	.....
21	3	.....	.....	.....	.....	5	.....	.....	.....	.....
22	D	.....	.....	.....	.....	.....	.....	.....	.....	.....
23	.....	.....	.....	.....	.....	1	.....	.....	.....	.....
24	.....	.....	.....	.....	.....	D	.....	.....	.....	.....
Totals	269	244	153	169	94	267	134	174	209	183
Averages	6.7	7.1	7.2	7.6	4.7	6.5	5.1	6.4	5.9	6.7

Life-History.—On the basis of seven individuals, the entire period from egg to adult was found to be 26.7 days, with a range of from 25 to 29 days. The different stages required approximately the following periods of time: egg stage, 5 days; first larval, 4.6 days; second larval, 2.9 days; third larval, 3.0 days; fourth larval, 5.6 days, and the pupal stage, 6.0 days. It will be observed that, while the total period required by the four specimens reared in May and three in August is practically identical, the early brood required approximately 5.75 days for the first larval stage and 2.25 days for the second, as compared with 3.0 and 3.7 days, respectively, for the later brood. All individuals were full-sized at time of emergence.

Life-History—*Adalia bipunctata* Linn.

Sacramento, 1913

No.	Date eggs laid	Eggs hatched	Length of stage, days	1st moult	Length of stage, days	2d moult	Length of stage, days	3d moult	Length of stage, days	4th moult (pupation)	Length of stage, days	Emerged	Length of pupal stage, days	Total days of stages
1	5/20	5/25	5	6/1	7	6/3	2	6/6	3	6/11	5	6/17	6	28
2	5/20	5/25	5	5/30	5	6/1	2	6/5	4	6/11	6	6/18	7	29
3	5/20	5/25	5	5/30	5	6/2	3	6/4	2	6/8	4	6/14	6	25
4	5/20	5/25	5	5/31	6	6/2	2	6/5	3	6/10	5	6/16	6	27
5	8/25	8/31	5	9/2	3	9/6	4	9/8	2	9/14	6	9/20	6	26
6	8/25	8/31	5	9/2	3	9/5	3	9/8	3	9/10	6	9/19	5	25
7	8/25	8/31	5	9/2	3	9/6	4	9/8	2	9/15	7	9/21	6	27
Average			5.0		4.6		2.9		3.0		5.6		6.0	26.7

Feeding Records.—The results from ten individuals throughout the entire larval period of approximately 22 days gave the maximum number of aphids eaten during the period as 308, the minimum 220, and the average 252. This gives an average of 14.1 aphids per day for the entire period. It will be observed in the table that a very sudden increase in the feeding took place about eight days after hatching, and this was found to correspond very closely to the time of the second moult, the number of aphids eaten was approximately doubled at this time.

The consumption of aphids by the ten adult beetles under observation ranged from 215 to 305, with an average of 251 aphids for the fifteen-day period. The largest number eaten in one day was 30, while the general daily average was 16.7 aphids.

Medium-sized rose aphids (*Macrosiphum rosae*) were used exclusively.

Larval Feeding Records—*Adalia bipunctata* Linn.

Riverside, 1914

Date	1	2	3	4	5	6	7	8	9	10
June 4	H	H	H	H	H	H	H	H	H	H
5	1	0	0	0	1	1	0	1	1	0
6	1	1	2	0	3	2	2	1	2	1
7	3	5	3	2	4	3	4	3	5	2
8	3	4	6	4	3	5	2	6	6	4
9	5	5	7	3	6	7	4	6	7	3
10	7	6	9	6	8	4	6	7	5	5
11	6	8	5	9	7	5	7	8	6	8
12	8	11	9	10	9	8	10	12	9	11
13	19	12	13	12	6	10	14	9	11	7
14	12	15	19	13	10	17	21	16	12	15
15	18	14	19	17	12	21	20	17	15	12
16	23	19	26	19	20	28	25	19	20	22
17	21	26	24	19	25	27	32	35	29	26
18	27	29	23	25	22	32	30	27	24	31
19	30	31	26	18	25	29	31	23	29	27
20	28	36	29	26	29	33	26	18	31	19
21	21	22	18	23	35	28	P	29	16	27
22	P	18	30	18	P	17	.....	33	12	P
23	.....	P	P	29	.....	P	.....	26	P	.....
24	.....	.....	.....	P	.....	.....	.....	12	.....	.....
25	.....	.....	.....	.....	.....	.....	.....	P	.....	.....
Total	233	262	268	253	225	277	234	308	240	220
Average	13.7	14.5	14.8	13.3	13.2	15.3	14.6	15.4	13.3	12.9

Adult Feeding Records—*Adalia bipunctata* Linn.

Berkeley, 1914

Date	1	2	3	4	5	6	7	8	9	10
April 1	16	12	18	10	6	14	18	15	11	16
2	12	9	14	12	15	11	16	10	13	8
3	24	20	17	21	18	22	20	17	16	19
4	18	12	16	15	7	11	10	14	13	7

Adult Feeding Records—*Adalia bipunctata* Linn.—(*Continued*)
Berkeley, 1914

Date	1	2	3	4	5	6	7	8	9	10
April 5	13	17	6	19	18	22	21	15	17	16
6	22	18	24	23	25	21	17	12	15	14
7	27	26	21	30	27	22	8	29	25	9
8	21	18	19	16	23	20	17	26	19	17
9	19	14	16	12	17	8	15	11	17	12
10	23	20	18	19	15	17	13	12	15	19
11	25	23	14	21	23	15	19	10	17	14
12	30	20	26	21	29	26	30	23	18	20
13	16	18	20	16	19	14	21	15	9	12
14	20	7	16	12	13	10	17	16	14	19
15	19	12	13	9	11	14	12	15	8	13
Total	305	246	258	256	266	247	254	240	227	215
Average	20.3	16.4	17.2	17.0	17.7	16.4	16.9	16.0	15.1	14.3

Cycloneda sanguinea Linn.

This species, while not particularly abundant in any part of the state, may be found quite generally distributed over the Sacramento and San Joaquin valleys and in certain coastal regions. The adults pass the winter singly in sheltered places upon trees and shrubs. The larvae have been observed feeding quite extensively upon the woolly apple aphis (*Schizoneura lanigera*), as well as the more common aphid species.

Oviposition.—The interval of time between emergence and mating in the ten specimens under observation ranged from one to three days, with an average of 1.9 days, while the period elapsing between mating and oviposition varied from seven to twelve days, averaging 10.1 days.

The period of oviposition extended from 19 to 42 days, averaging 28.8 days. The proportion of days upon which oviposition of the ten individuals actually occurred was 73.6 per cent, with a range of from 64.1 to 78.2 per cent of the total number of days of the adult life following the deposition of the first eggs. During this period the egg-production totals varied from 121 to 318, with a period average of 201 and a daily average of 7.0 eggs.

Egg-Laying Records—*Cycloneda sanguinea* Linn.

Berkeley, 1913

Date	1	2	3	4	5	6	7	8	9	10
Aug. 20	E	.....	.....	E	.....	E	E	.....	E	.....
21	M	E	.....	.....	E	.....	.....	.....	.....	E
22	.....	.....	E	M	M	.....	M	E	M	M
23	.....	.....	.....	.....	.....	M	.....	.....	.....	.....
24	.....	M	M	.....	.....	.....	.....	M	.....	.....
25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
26	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
27	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
28	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
29	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
30	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
31	5	3	.....	.....	2	.....	.....	.....	.....	.....
Sept. 1	8	2	.....	.....	8	.....	.....	.....	.....	.....
2	13	10	.....	4	7	1	.....	3	.....	5
3	.....	5	7	3	.....	3	5	7	7	3
4	19	.....	.....	12	14	5	9	6	.....	14
5	.....	6	11	6	9	2	11	.....	18	.....
6	12	4	14	.....	20	9	1	8	10	12
7	14	.....	5	.....	.....	14	6	10	9	5
8	.....	.....	6	10	11	6	13	14	11	18
9	20	11	.....	14	3	10	.....	.....	6	.....
10	7	23	12	7	15	.....	.....	5	.....	7
11	26	9	24	.....	24	3	8	13	18	.....
12	3	12	.....	16	.....	.....	2	15	.....	14
13	11	16	18	.....	8	5	20	.....	4	11
14	10	.....	16	19	.....	9	6	6	12	5
15	.....	15	9	4	13	.....	5	.....	3	19
16	7	10	11	8	7	14	.....	19	17	.....
17	13	4	.....	3	10	.....	9	.....	9	8
18	9	8	15	.....	16	5	11	14	18	.....
19	.....	6	.....	7	9	13	.....	12	.....	16
20	12	15	9	6	12	17	7	.....	11	13
21	.....	.....	4	2	.....	6	.....	2	15	.....
22	19	2	6	D	4	.....	8	3	14	5
23	6	14	.....	.....	21	3	12	D	8	.....
24	.....	2	.....	.....	2	14	.....	.....	2	.....
25	5	7	5	.....	8	.....	9	.....	13	D
26	1	14	1	.....	.....	7	18	.....	.....	.....
27	.....	.....	D	.....	11	6	6	.....	7	.....
28	D	5	.....	.....	14	4	.....	.....	18	.....
29	.....	3	.....	.....	19	.....	14	.....	.....	.....
30	.....	.....	.....	.....	5	9	10	.....	9	.....
Oct. 1	.....	1	.....	.....	.....	13	.....	.....	16	.....
2	.....	D	.....	.....	6	.....	8	.....	.....	.....

Egg-Laying Records—*Cycloneda sanguinea* Linn.—(*Continued*)

Berkeley, 1913

Date	1	2	3	4	5	6	7	8	9	10
Oct. 3	.....	.....	.....	.....	10	2	.....	.....	8	.....
4	.....	.....	.....	.....	.....	.....	D	.....	.....	.....
5	.....	.....	.....	.....	18	.....	.....	.....	19	.....
6	.....	.....	.....	.....	6	D	.....	.....	12	.....
7	.....	.....	.....	.....	2	.....	.....	.....	7	.....
8	.....	.....	.....	.....	.....	.....	.....	.....	6	.....
9	.....	.....	.....	.....	3	.....	.....	.....	.....	.....
10	.....	.....	.....	.....	1	.....	.....	.....	1	.....
11	.....	.....	.....	.....	.....	.....	.....	.....	D	.....
12	.....	.....	.....	.....	D	.....	.....	.....	.....	.....
Total	220	207	173	121	318	180	198	137	308	155
Average	7.8	6.4	7.2	6.0	7.5	5.2	6.4	6.5	8.1	6.7

Life-History.—In the following table is given the results of two series of life-history experiments, the results of which are quite noticeable in their difference. The eggs for the first set, of which three survived, were secured May 1 and hatched six days later. The first larval period varied in length from five to six days, the second from four to nine days, the third from three to five days, the fourth from five to eight days, and the pupal period from five to seven days. It will be noted that the variation in the second and fourth stages was very great, but the inverse ratio seemed to exist in the remaining stages, so that the complete life cycles for the three individuals varied only two days. In the remaining cases the egg stage required only five days, the first larval period a constant four days, the second period two to three days, the third period two to three days, the fourth period three to five days, and the pupal period three to four days, giving a total of from 20 to 23 days, as compared with 33 to 35 days with those reared seven weeks previously. The difference in mean temperatures at the time of the two series of experiments was approximately 10° F.

Life-History—*Cycloneda sanguinea* Linn.

Sacramento, 1913

No.	Date eggs laid	Eggs hatched	Length of stage, days	1st moult	Length of stage, days	2d moult	Length of stage, days	3d moult	Length of stage, days	4th moult (pupation)	Length of stage, days	Emerged	Length of pupal stage, days	Total days of stages
1	5/1	5/7	6	5/12	5	5/21	9	5/26	5	6/3	8	6/10	7	35
2	5/1	5/7	6	5/13	6	5/21	8	5/24	3	5/29	5	6/3	5	33
3	5/1	5/7	6	5/13	6	5/17	4	5/22	5	5/29	7	6/3	5	33
4	6/24	6/29	5	7/3	4	7/5	2	7/8	3	7/12	4	7/15	3	21
5	6/24	6/29	5	7/3	4	7/5	2	7/8	3	7/12	4	7/16	4	22
6	6/24	6/29	5	7/3	4	7/5	2	7/8	3	7/11	3	7/14	3	20
7	6/24	6/29	5	7/3	4	7/6	3	7/9	3	7/13	4	7/17	4	23
8	6/24	6/29	5	7/3	4	7/5	2	7/7	2	7/11	4	7/15	4	21
9	6/24	6/29	5	7/3	4	7/6	3	7/8	2	7/13	5	7/16	3	22
10	6/24	6/29	5	7/3	4	7/5	2	7/8	3	7/13	5	7/17	4	23
Average			5.3		4.5		3.7		3.2		4.9		4.2	25.3

Feeding Habits.—Complete feeding records were secured of ten individuals for the entire larval period, and the range in the number of aphids eaten was from 147 to 427, with an average of 216 aphids for the period. The daily average, computed upon the basis of approximately twenty days, was 14.5 aphids.

The feeding tests of ten adult beetles for a period of fifteen days gave a variation of from 205 to 260 aphids eaten, a rather unusual uniformity. The period average was 234, and, on a daily basis, 15.6 aphids. The daily individual average ranged from 8 to 30, with a general average of 15.6 aphids per day.

Larval Feeding Records—*Cycloneda sanguinea* Linn.

Sacramento, 1913

Date	1	2	3	Date	4	5	6	7	8	9	10
May 7	H	H	H	June 29	H	H	H	H	H	H	H
8	.....	.....	.....	30	2	1	1	0	2	1	1
9	3	3	2	July 1	2	4	3	1	3	4	1
10	6	8	5	2	6	9	8	5	11	7	6
11	1	1	3	3	4*	12*	8*	10*	9*	12*	8*
12	8	4	7	4	13	17	9	6	14	11	15
13	7	7*	6*	5	8*	13*	16*	9	14*	19	15*
14	7	8	5	6	7	9	6	7*	7	11*	6
15	3	4	9	7	13	21	18	16	23*	9	17
16	8*	9	7	8	19*	31*	24*	17	26	18*	32*
17	7	11	9*	9	26	39	32	28*	34	28	19
18	9	6	8	10	32	36	22	37	13	26	24
19	8	10	8	11	17	8	P	42	P	33	31
20	8	7	15	12	P	P	.....	21	.....	27	19
21	9	10*	12	13	.....	.....	.....	P	.....	P	P

Larval Feeding Records—*Cycloneda sanguinea* Linn.—(*Continued*)

Sacramento, 1913

Date	1	2	3	Date	4	5	6	7	8	9	10
May 22	15	19	18*	14	.....	.....	E	.....	.....	.....	.....
23	17	16	15	15	E	.....	.....	.....	E	.....	.....
24	23*	29*	29	16	.....	E	.....	.....	.....	E	.....
25	41	39	36	17	.....	.....	.....	E	.....	.....	E
26	27*	46	35	18	.....	.....	.....	.....	.....	.....	.....
27	23	21	16	19	.....	.....	.....	.....	.....	.....	.....
28	44	P	.....								
29	50	.....	P								
30	47	.....	.....								
31	32	.....	.....								
June 1	15	.....	.....								
2	.....	.....	.....								
3	P	E	E								
4	.....	.....	.....								
5	.....	.....	.....								
6	.....	.....	.....								
7	.....	.....	.....								
8	.....	.....	.....								
9	.....	.....	.....								
10	E	.....	.....								
Total	418	258	245		149	200	147	199	156	206	194
Average	16.7	12.9	12.2		12.4	16.6	13.3	15.3	14.1	15.8	14.9

Adult Feeding Record—*Cycloneda sanguinea* Linn.

Riverside, 1914

Date	1	2	3	4	5	6	7	8	9	10
May 16	12	19	15	8	14	17	19	7	11	14
17	16	12	6	14	16	23	12	16	19	18
18	14	18	13	17	11	16	14	12	22	12
19	22	12	10	16	22	19	22	19	15	16
20	19	17	18	14	13	18	15	24	12	18
21	16	26	17	19	17	12	17	26	17	21
22	13	14	15	11	12	15	10	16	21	15
23	18	18	20	9	14	11	18	17	12	17
24	26	15	11	8	10	14	24	18	16	10
25	15	12	16	13	19	30	16	12	19	8
26	19	14	19	15	15	9	21	20	15	17
27	11	11	15	13	17	13	12	17	23	12
28	17	18	14	17	11	16	13	19	16	15
29	14	20	12	16	14	21	17	14	8	14
30	19	16	8	15	20	12	19	23	12	9
Total	251	242	209	205	225	246	249	260	238	216
Average	16.7	16.1	13.9	13.6	15.0	16.3	16.6	17.3	15.8	14.4

Comparative Records

Time from Emergence to Mating and Egg-laying.—Complete data in regard to these periods were secured for only five of the species under investigation. In the case of *Hippodamia convergens* and *Olla oculata*, records were secured only in regard to the time from mating to egg-laying, and none whatever in the case of *Coccinella trifasciata*. The periods varied only to a comparatively slight extent between the different species. From emergence to mating the usual intervening period was one to three days, the averages ranging from 1.6 days in the case of *Adalia bipunctata* to 2.7 days for *Coccinella californica*. From mating to oviposition a corresponding variation occurred, the shortest time being seven days for *Cycloneda sanguinea* and *Olla abdominalis*. The general averages for the different species varied from 8.6 for *Olla oculata* to 11.9 days for *Coccinella californica*.

Emergence to Mating and Egg-Laying

	Number specimens	Emergence to mating days			Mating to egg-laying days		
		Max.	Min.	Aver.	Max.	Min.	Aver.
Coccinella californica	10	3.0	2.0	2.7	14.0	10.0	11.9
Hippodamia convergens	6	....	....	....	13.0	8.0	10.5
H. ambigua	9	3.0	1.0	1.7	11.0	8.0	9.6
Olla abdominalis	9	3.0	1.0	1.7	10.0	7.0	8.6
O. oculata	9	....	....	....	13.0	8.0	10.7
Adalia bipunctata	10	2.0	1.0	1.6	11.0	8.0	9.6
Cycloneda sanguinea	10	3.0	1.0	1.9	12.0	7.0	10.1

Periods of Oviposition.—The period over which egg-laying will extend is largely dependent upon the conditions under which the individuals exist. Egg-laying normally takes place daily, with an occasional exception, approximately two weeks after emergence until death. Inasmuch as all the experiments upon this point were not conducted under similar conditions the results will naturally vary to a greater or less degree.

The maximum number of days included in the oviposition period was found to be 59 in the case of *Hippodamia ambigua*, *Coccinella californica* was second with 51, and *Adalia bipunctata* last with 39 days. The average number of days for the individuals of each species was 48.1 for *H. ambigua*, 35.4 for *Olla oculata* and last, *A. bipunctata* with 28.2 days to its credit.

The proportion of days upon which eggs were actually deposited was found not to have any direct bearing upon the comparative totals, the individuals of *Olla oculata* averaging 89.3 per cent as compared with *Hippodamia convergens* at 63.8 per cent, even though the final total laid was in favor of the latter by a margin of 48 eggs. The maximum proportion of days in which eggs were deposited by a single individual was 95.5, this also being to the credit of *O. oculata*. The minimum was 28.0 per cent in the case of *H. convergens*.

Periods of Oviposition

	Number specimens	Length of period, days			Proportion of days eggs deposited, per cent		
		Max.	Min.	Aver.	Max.	Min.	Aver.
C. californica	10	51	20	31.0	74.1	60.0	69.5
C. trifasciata	10	42	14	29.2	78.1	66.6	75.0
H. convergens	11	50	11	33.3	72.7	28.0	63.8
H. ambigua	8	59	25	48.1	75.0	48.2	61.4
O. abdominalis	9	47	19	34.7	73.8	66.0	70.3
O. oculata	9	46	17	35.4	95.5	84.3	89.3
A. bipunctata	10	39	20	28.2	76.3	60.0	69.4
C. sanguinea	10	42	19	28.8	78.2	64.1	73.6

Rate of Oviposition.—A very considerable difference was found to exist in the number of eggs deposited by the various species. As would be expected from field observations, several individuals of *Hippodamia convergens* deposited a considerably larger number of eggs than those of any other species, the maximum number secured from one female being 609 as compared with 489 from *Olla oculata*, the next highest. This difference, however, was not found to hold in regard to the general averages of all individuals of each species, inasmuch as *O. oculata* ranked first with 347, *Hippodamia ambigua* second with 312, and *H. convergens* third, with an average of 299 eggs for the full period. As regards the maximum number of eggs deposited in one day, it will be seen that *H. convergens* leads with 43, *Coccinella trifasciata* second with 31, and *O. oculata* last with 22 in one day.

Olla oculata ranks first in respect to the daily average for the entire period of oviposition, with 9.8 eggs per day, while the lowest average is 6.3 eggs per day in the case of *O. abdominalis*. General observations lead one to believe that *H. convergens* under field conditions is far more prolific than any of the other species.

The record of 1550 eggs deposited within a period of slightly over two months reported by E. K. Carnes[1] tends strongly to bear out this assumption.

Rate of Oviposition

	Number specimens	Daily records		Period records		
		Max.	Aver.	Max.	Min.	Aver.
C. californica	10	24.0	8.0	360	171	207
C. trifasciata	10	31.0	8.4	353	109	249
H. convergens	11	43.0	8.9	609	94	299
H. ambigua	8	24.0	7.3	421	199	312
O. abdominalis	9	25.0	6.3	298	130	234
O. oculata	9	22.0	9.8	489	171	347
A. bipunctata	10	23.0	6.7	269	94	190
C. sanguinea	10	26.0	7.0	318	121	201

Life-History.—In a comparative study of life-histories it is essential that due allowance be made for variations in conditions under which the experiments are carried on in case they are not made simultaneously. The records of *Hippodamia convergens*, *Coccinella californica*, *Olla oculata* and *Adalia bipunctata* were secured at Sacramento during the period from April 25 to August 20, 1913. Those of *Coccinella trifasciata* and *Hippodamia ambigua* were secured at Berkeley during the spring of 1914, while the life-history of *Olla oculata* was determined at Uplands during May and June, 1914. As regards climatic conditions in the three localities, Sacramento was considerably warmer than either of the other places, the temperature often reaching 105° F. and occasionally higher. At Uplands the conditions more nearly approached those best suited to the maximum development of the beetles, the average daily maximum temperature being approximately 85° to 90° F. At Berkeley the temperature was somewhat lower and the nights very cool.

In computing the period lengths in the table given below, the averages were taken of all individuals of each species and no particular account made of individual variations. No very great range was found in the egg stage, the longest period being 6.0 days for *Coccinella trifasciata* and the shortest 4.3 days for *Olla oculata*. The first larval stage required from 3.8 to 5.7 days, the members of the genus *Coccinella* apparently requiring longer

[1] E. K. Carnes, Monthly Bulletin, Calif. Hort. Com., Sept., 1912, p. 820.

than any other. In the second larval stage the variation was from 2.3 to 4.7 days, and no special differences are noticeable between the various genera. The third stage required a minimum of 2.3 days for *Hippodamia convergens* and a maximum of 4.2 days in the case of *Olla oculata*. *Coccinella* and *Hippodamia* required from 6.5 to 7.4 days for the fourth larval stage, as compared with 4.7 to 5.6 for the other genera, except for *Olla oculata*, which covered 7.0 days. The pupal stage required the longest time with *Hippodamia*, the average being 7.5 and 8.0 days, respectively, for the two species. The variation for the remaining species was from 3.5 to 6.0 days in the cases of *O. oculata* and *Adalia bipunctata*, respectively.

The complete life-cycle from egg to adult varied from 21.0 days in the case of *Olla abdominalis* to 33.2 days for *Hippodamia ambigua*. Strangely enough, the period lengths up to and including the third larval stage were approximately equal in all the species, but a very considerable range was presented in the fourth larval stage and pupal stage, resulting in the considerable difference between species as noted above. As stated previously, however, the possibility is very strong that this was, in part at least, due to the varying conditions under which the investigations were conducted.

Life-Histories

	Number specimens	Egg stage, days	Larval stage, days				Pupal stage, days	Total days
			First	Second	Third	Fourth		
C. californica	13	5.4	5.7	3.3	3.4	6.8	4.5	29.1
C. trifasciata	12	6.0	5.3	4.2	3.3	7.4	3.7	31.8
H. convergens	8	5.0	3.9	3.6	2.3	6.5	7.5	28.8
H. ambigua	10	5.5	3.8	4.7	3.6	7.3	8.0	33.2
O. abdominalis	14	4.2	3.3	2.3	2.8	4.7	3.5	21.0
O. oculata	11	5.0	4.6	4.3	4.2	7.0	5.1	30.2
A. bipunctata	7	5.0	4.6	2.9	3.0	5.6	6.0	26.7
C. sanguinea	10	5.3	4.5	3.7	3.2	4.9	4.2	25.3

Larval Feeding Records.—Individual feeding records were secured for the entire larval period for the different species in numbers ranging from eight for *Hippodamia ambigua* to fourteen for *Olla abdominalis*. In the case of each species, enough tests were started to secure approximately ten complete records making due allowance for the possible mortality during the larval period. In the following tabulation the length of the

larval period is given to facilitate a comparison of the daily records. The period averages ranged from 475 aphids for *Coccinella californica* to 216 as a minimum for *Cycloneda sanguinea*. The maximum individual record was 580 and the minimum 147 for the two above-named species, respectively. Feeding in the case of *Olla oculata* was very regular, the difference between the limits of the ten individuals being only 50 aphids for the period, while a difference of 280 was noted in the case of *Cycloneda sanguinea*. In regard to *Coccinella californica*, it must be remembered that for a period of one to three days previous to pupation no aphids were eaten, a condition which considerably reduced the daily average as compared with other species which fed normally up to the day of pupation. In spite of this, *C. californica* heads the list with 24.9 aphids per day for the entire period; *H. convergens* is second with 20.7; and *H. ambigua* last with 11.4 per day.

Larval Feeding Records

	Number specimens	Length of period, days	Period totals		Averages	
			Max., aphids	Min., aphids	Period, aphids	Daily, aphids
C. californica	13	23.7	600	394	475	24.9
C. trifasciata	12	25.8	365	217	294	15.8
H. convergens	12	23.8	490	232	349	20.7
H. ambigua	8	27.7	392	269	312	11.4
O. abdominalis	14	16.7	256	196	240	19.8
O. oculata	10	25.2	349	299	326	17.2
A. bipunctata	10	21.7	308	220	252	14.1
C. sanguinea	10	20.0	427	147	216	14.5

Adult Feeding Records.—The feeding records for the adults of the various species as given in the following table are for a period of fifteen days with the exception of *Hippodamia convergens*, an eight-day record of which was taken from the complete adult feeding data of individuals from storage, as previously explained in the discussion of that species. The number of beetles of the different species ranged from seven for *H. convergens*, and nine for *Olla abdominalis* to ten in the case of the other species. The maximum period average was 624 aphids for *Olla oculata*, while the minimum was 234 to the credit of *Cycloneda sanguinea*. The individual maximum was 672 and the minimum 205 aphids, respectively, for the same two species above

named. On a daily basis the variation extended from 56.1 aphids for *H. convergens* to 15.6 for *C. sanguinea.* In general it may be said that the number of aphids eaten varied practically in direct proportion to the size of the individuals, though a conspicuous exception to this generalization may be noted in the case of *Coccinella californica,* with a record of only 34.0 aphids per day.

Adult Feeding Records

	Number specimens	Length of period, days	Period totals		Averages	
			Max., aphids	Min., aphids	Period, aphids	Daily, aphids
C. californica	10	15	661	414	500	34.0
C. trifasciata	10	15	470	383	435	28.9
H. convergens	6	8	515	380	449	56.1
H. ambigua	10	15	429	370	397	26.5
O. abdominalis	9	15	534	407	457	30.4
O. oculata	10	15	672	589	624	41.6
A. bipunctata	10	15	355	215	251	16.7
C. sanguinea	10	15	260	205	234	15.6

Measurements.—In the following table is given the measurements of the egg, full-grown larva, and adult of each species. In every case the figure given represents the average of ten individuals, and particular care was taken to secure larvae of normal development. The variation in length of eggs was comparatively slight, those of *Adalia bipunctata* and *Cycloneda sanguinea* measuring 1.3 mm., of *Coccinella californica* 1.5 mm., and of the remaining species 1.4 mm. The larvae ranged in size from 6.0 mm. for *Cycloneda sanguinea* to 10.2 mm. in the case of *Coccinella californica.* This ratio also held for the adults, *C. sanguinea* measuring 4.5 mm. and *C. californica* 8.0 mm.

Comparative Measurements

	Egg	Larva	Adult
C. californica	1.5 mm.	10.2 mm.	8.0 mm.
C. trifasciata	1.4	8.0	6.5
H. convergens	1.4	8.2	7.0
H. ambigua	1.4	8.1	7.0
O. abdominalis	1.4	7.1	6.0
O. oculata	1.4	7.0	6.5
A. bipunctata	1.3	6.0	5.0
C. sanguinea	1.3	6.3	4.5

SUMMARY

Some of the main points determined in the investigations as herein outlined may be briefly stated as follows.

1. The life-history of an aphid-feeding coccinellid under normal summer conditions in California, based upon the results secured from eight species, may be given as twenty-seven days, divided as follows: egg stage, five days; first larval stage, five days; second, three days; third, three days; fourth, six days, and the pupal stage five days.

2. The number of aphids eaten by the larvae of the different species is in proportion to the size of the individuals.

3. The above, to a limited extent, may be said to be true in the case of the adults also.

4. Temperature and humidity are very strong contributing factors in the development and behavior of the various species.

5. The number of eggs to be expected under normal field conditions will vary from 200 to 500, or occasionally more, and extending over a period of from four to eight weeks where the female has lived the full adult life under optimum conditions.

6. The period intervening between emergence and mating is one to three days, and from mating to oviposition, eight to eleven days, thus giving a period of from ten to fifteen days after emergence before oviposition may be expected.

7. Oviposition normally takes place daily, with occasional exceptions.

8. Only one fertilization is necessary during the life of the female, fertile eggs having been produced in one instance fifty-five days after mating.

Transmitted September 25, 1915.

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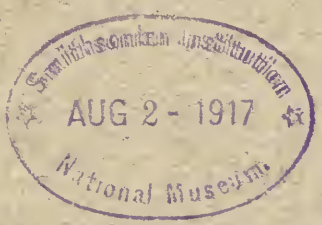
TECHNICAL BULLETINS
COLLEGE OF AGRICULTURE, AGRICULTURAL EXPERIMENT STATION
ENTOMOLOGY
Vol. 1, No. 7, pp. 301-346 July 20, 1917

APHIDIDAE OF CALIFORNIA

NEW SPECIES OF APHIDIDAE AND NOTES FROM VARIOUS PARTS OF THE STATE, BUT CHIEFLY FROM THE CAMPUS OF THE UNIVERSITY OF CALIFORNIA, BERKELEY, CALIFORNIA

BY
E. O. ESSIG



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TECHNICAL BULLETINS

COLLEGE OF AGRICULTURE, AGRICULTURAL EXPERIMENT STATION

ENTOMOLOGY

Vol. 1, No. 7, pp. 301-346 July 20, 1917

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NEW SPECIES OF APHIDIDAE AND NOTES FROM VARIOUS PARTS OF THE STATE, BUT CHIEFLY FROM THE CAMPUS OF THE UNIVERSITY OF CALIFORNIA, BERKELEY, CALIFORNIA

BY

E. O. ESSIG

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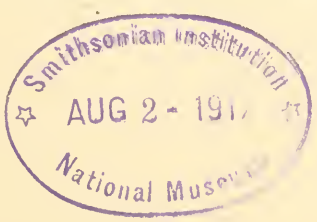
[1] This paper is No. XI in the author's series "Aphididae of California," published in the *Pomona Journal of Entomology and Zoology.*



INTRODUCTION

California offers a specially inviting field for the study of the *Aphididae* not only because of the comparatively large number of new species yet undescribed, but also because of the great and varied adaptations constantly going on to the everchanging vegetation at the hand of man. The campus of the University of California with its many native plants growing under perfectly natural conditions and the hundreds of introduced species, together with numerous parks such as Golden Gate Park, San Francisco, furnish large and excellent fields for study and investigation. In such environment there are not only many new species of insects to be had, but there are the constant changes of food plants and distribution of old and well known species. The material at hand was taken under such conditions and represents but a small part of a season's work. Unless otherwise specified the data was taken in the field by the writer.

DESCRIPTION OF NEW SPECIES

Myzocallis arundinariae, n. sp.

1. Davidson, W. M., Jour. Econ. Ent., vol. 2, p. 301, 1909, *Callipterus arundicolens* (Clarke).
2. Essig, E. O., Pom. Coll. Jour. Ent., vol. 4, no. 3, p. 762, 1912, *Myzocallis arundicolens* (Clarke).
3. Essig, E. O., Inj. & Ben. Ins. Cal., ed. 1, p. 83, 1913, fig. 65, *Myzocallis arundicolens* (Clarke).
4. Davidson, W. M., Jour. Econ. Ent., vol. 7, pp. 129–130, 1914, fig. 2, *Eucallipterus arundicolens* (Clarke).
5. Essig, E. O., Inj. & Ben. Ins. Cal., ed. 2, p. 84, 1915, fig. 67, *Myzocallis arundicolens* (Clarke).

During the year 1911 the writer received from Mr. C. W. Beers, Horticultural Commissioner of Santa Barbara County, a few leaves of bamboo taken at Carpinteria, California, and infested with a yellow and black plant louse which agreed so well with the description of *Callipterus arundicolens* (Clarke)[2] that it was unquestionably listed as that species. The same insect was taken and received by the writer from a number of localities throughout the state since that time, but it was not until the past year, when a close study of the species described by Professor

[2] Can. Ent., vol. 35, p. 249, 1903.

Clarke was made in the type locality at Berkeley, that it was discovered that the former insect had some marked and constant characters not common to the latter and that the differences were sufficient to separate the two. The former has therefore been described as a new species, *Myzocallis arundinariae* from the generic name of the bamboo most commonly infested. Only the winged viviparous females—virgogeniae—could be secured, though the writer made a special trip to Sacramento where he had previously taken the species, and enlisted aid from all pos-

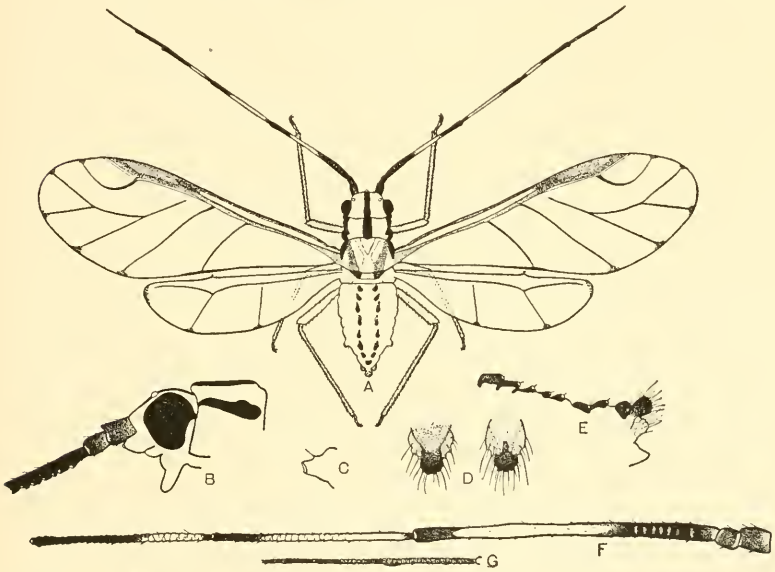


Fig. 1. *Myzocallis arindinariae*, n. sp. Winged viviparous female. *A*, adult; *B*, lateral aspect of head showing protuberance; *C*, cornicle; *D*, cauda and anal plate; *E*, lateral view of the dorsum of the abdomen showing dark tubercles and cauda; F, and G, antenna. (Original.)

sible sources in the attempt. The apparent absence of sexuales is also in contrast to *Myzocallis arundicolens* (Clarke) which had an abundance at this time.

WINGED VIVIPAROUS FEMALE—VIRGOGENIA

The color varies from whitish to pale yellow with noticeable black markings and bright red compound eyes. The average length is 1.4 mm. and the width near the base of the abdomen 0.4 mm. The head is often slightly dusky and has two lateral and a dorsal longitudinal black vittae. The antennae (fig. 1,

F, *G*) are yellow and black and often covered with a white fluffy material giving a bluish cast to the black beneath. Articles I, II and VI are dusky, while all of III excepting the middle is black and IV and V are black at the extreme bases and the apices. The length of the antennae is more than twice that of the body; that of the respective articles being: I 0.1 mm., II 0.08 mm., III 0.98 mm., IV 0.65 mm., V 0.58 mm., VI 0.64 mm. (base 0.29 mm., filament 0.35 mm.), total 3.03 mm. The sensoria are transversely oval and variable in size, but the majority are about equal in length to half the width of the article. On Article III there are from four to nine confined to the basal third. The following tabulation will give an idea of the number on the pairs of antennae of forty-four individuals, the colon separating the individuals and the comma the articles. 7, 7 : 6, 5 : 5, 5 : 6, 6 : 7, 9 : 7, 7 : 6, 6 : 5, 5 : 5, 5 : 5, 5 : 7, 8 : 8, 8 : 7, 8 : 7, 8 : 6, 6 : 7, 9 : 7, 7 : 6, 8 : 6, 7 : 6, 7 : 4, 5 : 6, 6 : 6, 5 : 5, 7 : 6, 7 : 5, 5 : 6, 7 : 4, 7 : 4, 5 : 6, 7 : 5, 7 : 4, 6 : 5, 5 : 5, 5 : 5, 6 : 5, 6 : 6, 7 : 5, 6 : 6, 7 : 6, 6 : 6, 6 : 6, 7 : 5, 6 : 6, 7. The usual number occur on articles V and VI. There are but few very inconspicuous hairs on the antennae. A very large protuberance is located on the underside of the head just in front of the rostrum (fig. 1, *B*) which it equals in length. The rostrum is very short, reaching only to the front coxae. The thorax is yellow with amber or slightly dusky muscle lobes and a dark vitta on each side in front of the bases of the wings and two indistinct dusky lines on the dorsum. The venation of the wings is shown in the accompanying drawing (fig. 1, *A*). The legs are yellow with the apical portions of the tarsi dusky. The abdomen has two longitudinal rows of dorsal tubercles (fig. 1, *A*, *E*,); there being eight separate pairs and one large patch made by the fusing of the ninth pair. A small hair or spire arises from each of the dark areas and two from the largest posterior one. The cornicles (fig. 1, *C*) are yellow, short and much wider at the base than at the mouth. A very long hair arises from a tubercle near the middle of the hind margin. The length is 0.1 mm. The cauda (fig. 1, *D*) is knobbed and conspicuously dusky or black. The anal plate (fig. 1, *D*) is distinctly bilobed and pale or dusky yellow.

The nymphs are pale yellow or very bright amber in color and covered with numerous long knobbed spines or hairs.

HOSTS, LOCALITIES, DATES AND COLLECTORS

1. Bamboo, *Arundo*, sp., Stanford University, Cal., October, 1908?. W. M. Davidson.[3]
2. Bamboo, *Arundinaria*, sp.?, Carpinteria, Cal., July 20, 1911. C. W. Beers.
3. Bamboo, *Arundo*, sp., San José, Cal., Oct. 15, 1911. W. M. Davidson.
4. Bamboo, *Arundinaria japonica* S. & Z., Capitol Park, Sacramento, Cal., April 30, 1912. The writer.
5. Bamboo, *Arundo*, sp.?, Exposition Park, San Diego, Cal., April 27, 1916. A. F. Swain.
6. Bamboo, *Arundinaria*, sp.?. Montecito, Cal., June 27, 1916. C. W. Beers.
7. Bamboo, *Arundinaria japonica* S. & Z., Capitol Park, Sacramento, Cal., Dec. 14, 1916. The writer.

The writer has also had reports of its occurrence elsewhere in Southern California but has not been able to verify them.

In all cases the insects work on the leaves, usually the undersides, and produce sufficient honey-dew to cause considerable smutting.

COTYPES

All of the descriptions made by the author have been from a series of individuals which of course become cotypes. These have been placed in the collections of the U. S. National Museum, Washington, D. C., and the California Academy of Sciences, San Francisco, Cal., while a good series in each case has remained in the author's collection. In case of the species herein described they have been deposited as directed above.

Myzocallis arundicolens (Clarke)

WINGED VIVIPAROUS FEMALE—VIRGOGENIA

1. Clarke, W. T. (orig. desc.), Can. Ent., vol. 35, p. 249, 1903, *Callipterus*.
2. Essig, E. O. (host index), Pom. Coll. Jour. Ent., vol. 3, no. 2, p. 458, 1911, *Callipterus*.
3. Essig, E. O. (list), Pom. Coll. Jour. Ent., vol. 4, no. 3, p. 263, 1912.

The color of the winged viviparous female is from whitish to pale lemon-yellow with bright red compound eyes, a pitch

[3] The writer received a mounted slide of specimens taken by Mr. Davidson at San José, California, which proved to be this species. These specimens are probably the same as those which he also took at Palo Alto as recorded above.

black cauda and black or dusky antennal markings. It very much resembles the corresponding form of the preceding species in size, color and shape, but lacks the black tubercles on the dorsum and has the sensoria on article III of the antennae grouped about one-third the distance from the base instead of being confined to the basal third (fig. 2, *D*). The number of sensoria is also smaller as will be seen from the following tabulation of thirty-one individuals 6, 6 : 7, 7 : 5, 5 : 6, 8 : 4, 5 : 4, 4 : 5,

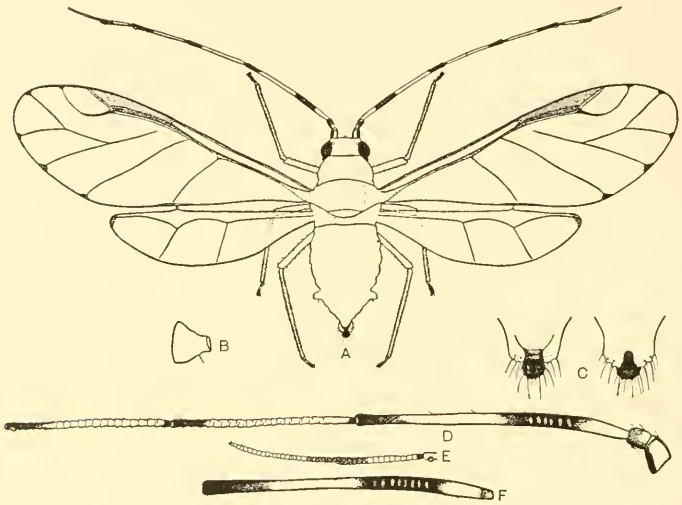


Fig. 2. *Myzocallis arundicolens* (Clarke). Winged viviparous female. *A*, adult; *B*, cornicle; *C*, cauda, and anal plate; *D* and *E*, antenna; *F*, article III of the antenna of a sexupara.

6 : 5, 6 : 5, 6 : 6, 6 : 5, 5 : 6, 6 : 5, 6 : 6, 6 : 7, 8 : 5, 6 : 5, 6 : 6, 7 : 5, 6 : 6, 6 : 4, 6 : 6, 6 : 6, 6 : 5, 6 : 5, 6 : 6, 6 : 5, 6 : 5, 6 : 5, 6 : 6, 8 : 6, 7. The stigma of the wings usually lack the darker spots at the base which is so constant in *Myzocallis arundinariae*, and the cauda is usually blacker.

SEXUPARA

Fig. 2, *F*

The sexupara is very much like the virgogenia, but is usually a little larger. There are also more sensoria on article III of the antennae (fig. 2, *F*) as shown by the following tabulation of eighteen individuals: 7, 8 : 10, 10 : 7, 7 : 8, 9 : 6, 9 : 8, 9 : 6, 10 : 7, 8 : 8, 9 : 7, 9 : 8, 9 : 8, 9 : 9, 10 : 8, 9 : 8, 8 : 7, 10.

SEXUALES

Female

The sexual female is large, robust and apterous, varying from whitish to very pale yellow and immaculate excepting the dark patches on the antennae and tarsi as well as the pitch black cauda. The length averages 2mm. and the width 1.3 mm. The dorsum has four longitudinal rows of hair-like spines which arise from quite large tubercles. The antennae (fig. 3, *C*, *D*) are longer than the body, the individual articles being as follows: I 0.11 mm., II 0.07 mm., III 0.9 mm., IV 0.57 mm., V 0.5 mm., VI 0.66

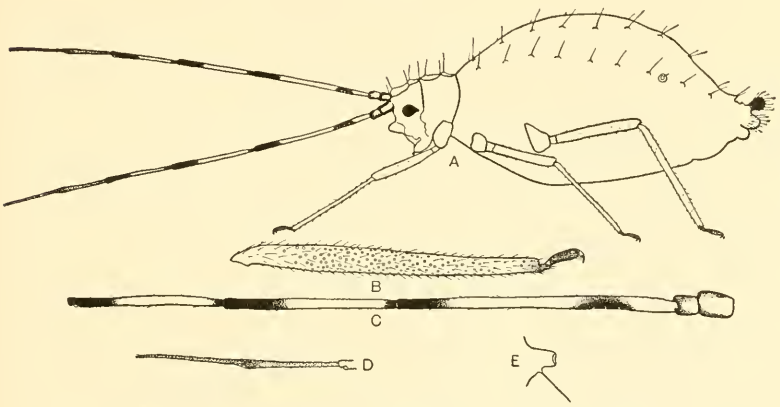


Fig. 3. *Myzocallis arundicolens* (Clarke). Sexual female. *A*, side view; *B*, hind tibia showing sensoria; *C* and *D*, antenna; *E*, cornicle. (Original.)

mm. (base 0.31 mm., filament 0.35 mm.), total 2.81 mm. The sensoria are transversely oval and similarly located as in the other forms, but are fewer in number, varying from none at all to three or four. The hind tibiae (fig. 3, *B*) are swollen and covered with a great many small circular sensoria.

Eggs

The eggs are pale yellow or whitish when first laid, but soon become shining black. They are oval with a conspicuous blunt stipe or pedicel at one end. The length averages 0.07 mm. They are deposited singly, in uneven masses or more often in rows on the undersides of the leaves and are at once conspicuous to the naked eye.

Male

The male is winged and much darker in color than any of the other forms. The average length is 1.5 mm. The head and articles I, II and VI of the antennae are dusky, while article III is almost black throughout, the apical half of IV is also black

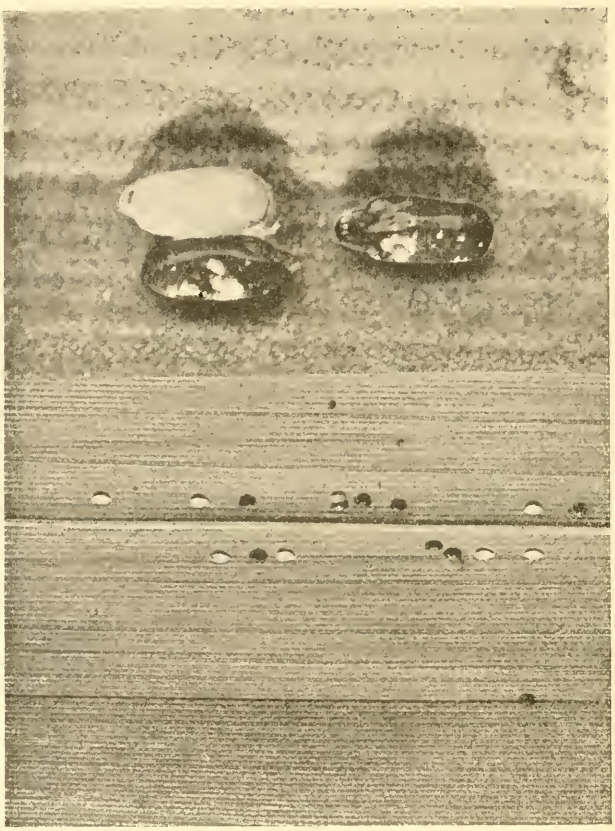


Fig. 4. *Myzocallis arundicolens* (Clarke). Eggs. The pale ones are freshly laid and become black soon afterwards. Three are greatly enlarged to show the pedicel at one end. (Original. Photo by Div. Sci. Illust., Univ. Calif.)

and V is a little darker than VI. The antennae (fig. 5, *B–E*) are much longer than the body, the lengths of the respective articles being: I 0.07 mm., II, 0.07 mm., III 0.93 mm., IV 0.58 mm., V 0.48 mm., VI 0.68 mm. (base 0.31 mm., filament 0.37 mm.), total 2.81 mm. The sensoria are transversely oval and numerous on

article III, numbering from 21 to 30 and covering the entire length excepting the extreme base. On article IV there are from 3 to 8 which are usually confined to the apical two-thirds of the joint. On article V there are from 2 to 9 distributed indefinitely along the entire length. There are from 1 to 6, not including those in the process, on article VI located usually near the middle of the base. The following tabulation, which does not include the sensoria in the process of VI, will serve to give an idea of the variation in numbers on the respective articles:

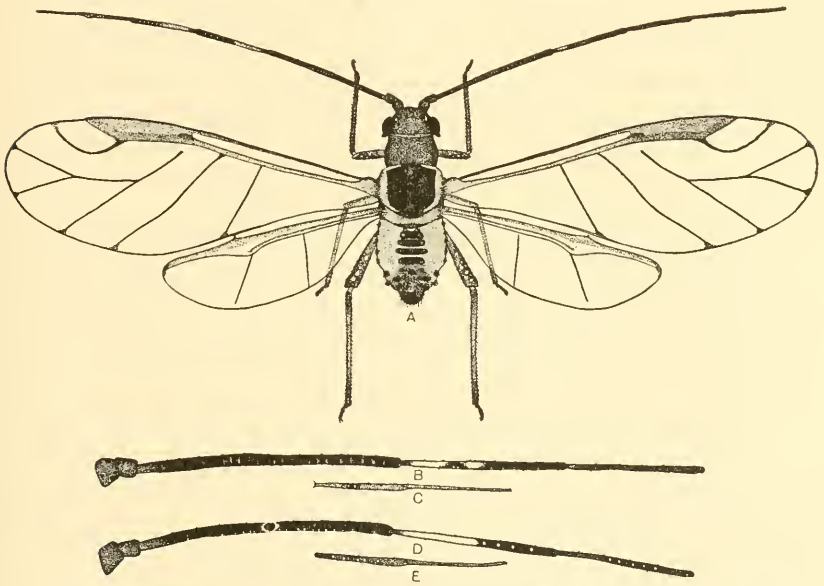


Fig. 5. *Myzocallis arundicolens* (Clarke). Male. *A*, dorsal aspect; *B E*, antennae. (Original.)

Individuals	III	IV	V	VI
1	27	3	8	2
	26	4	8	2
2	29	5	9	3
	26	6	5	3
3	25	7	6	2
	25	4	6	6
4	21	8	5	2
	25	4	6	5
5	26	3	5	3
	26	7	6	3
6	28	5	2	2
	25	6	4	2

Individuals	III	IV	V	VI
7	26	3	9	3
	28	6	7	3
8	28	6	8	article missing
	30	3	7	2
9	24	4	7	article missing
	29	7	8	article missing
10	24	4	5	article missing
	26	5	8	article missing
11	25	4	6	1
	26	5	7	2

The legs are quite long, dusky yellow with almost black femora which have rather prominent oval or circular pale areas showing specially well in the mounted specimens. The thorax is yellow or dusky with brown or black muscle lobes. The abdomen is yellow with black spots along the margins and numerous black patches on the dorsum usually arranged in transverse rows. The cornicles are short and dusky yellow. The cauda and anal plates are from dusky to pitch black. Short spines arise from the dusky areas on the dorsum, being arranged in longitudinal rows.

HOST PLANTS, LOCALITIES, DATES AND COLLECTORS

1. Bamboo, *Arundo,* sp.,[4] Berkeley, Cal., 1903. W. T. Clarke.
2. Bamboo, *Arundinaria japonica* S. & Z., U. C. Campus, Berkeley, Cal., 1916. Different forms taken by the writer as follows:

   Virgogeniae—Abundant on the undersides of the leaves throughout the summer and fall. Those described were collected on June 1 and July 17.

   Sexuparae—Quite numerous in the late fall. Collected Nov. 28 and 29 and Dec. 28.

   Sexuales—The females abundant from the last of October to the first of December and a few stragglers remaining until after January 1. Collected Nov. 28 and 29 and Dec. 28. The males not abundant at any season, but most numerous about the middle of November. Collected Nov. 28, and 29. None were to be found as late as Dec. 28.

   Eggs were laid the last of October and a few still being deposited in late December, but on Dec. 28 very few freshly laid eggs could be found, practically all having already assumed the shiny black color.

[4] This plant is undoubtedly *Arundinaria japonica* S. & Z., which is the common species infested on the campus where the type specimens were also taken.

Symydobius[5] agrifoliae, n. sp.

This species was first collected by S. H. Essig and the writer in 1911, but as only apterous forms were secured at that time no attempt was made to describe it. During the spring of 1916 a number of winged and apterous viviparous females were taken by S. H. Essig and forwarded to the writer. As previously believed it proved to be a new species, which I am naming after the species of the host plant. It is with gratitude here that I acknowledge the great help constantly given by my brother mentioned above.

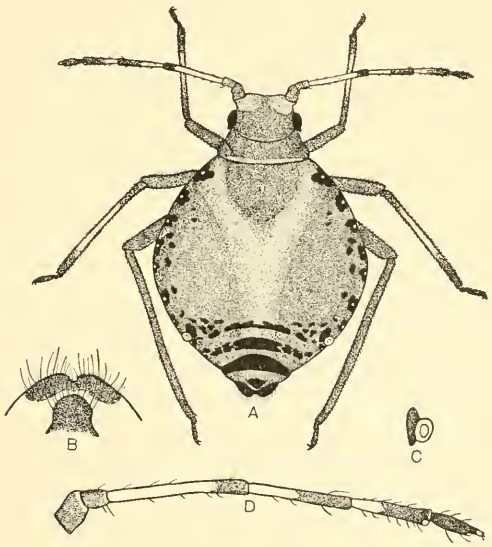


Fig. 6. *Symydobius agrifoliae,* n. sp. Apterous viviparous female. *A,* dorsal aspect; *B,* cauda and anal plate; *C,* cornicle; *D,* antenna. (Original.)

APTEROUS VIVIPAROUS FEMALE—VIRGOGENIA

The mature apterous female is rather robust and of a dark reddish brown color with lighter amber or yellowish markings describing roughly the letter Y on the back. The dorsum and sides are also obscurely marked with black blotches. The length averages about 1.6 mm., and the greatest width is 1.1 mm. The head is rather narrow and pale amber at the bases of the antennae. The eyes are dark red. The antennae (fig. 6, *D*) are

[5] The genus *Symydobius* has been wrongly spelled *Symdobius* in the author's former articles.

dusky with the greater portion of article III and the bases of articles IV and V pale. The length is nearly as great as that of the body, the measurements of the respective articles being: I 0.08 mm., II 0.07 mm., III 0.41 mm., IV 0.3 mm., V 0.26 mm., VI 0.16 mm. (base 0.13 mm., spur 0.03 mm.), total 1.28 mm. There is considerable variation in the measurements of different individuals, but the relative lengths are fairly constant. The usual sensoria are present on articles V and VI, but very few hairs are present on any of the articles. The rostrum is light amber in color and reaches slightly beyond the third coxae. The legs are rather short and dark brown with lighter areas in the middle of the tibiae of most specimens. The cornicles (fig. 6, *C*) are dark, very short, wide at the base and narrow at the mouth, which has a very wide lip or flange and small opening. The cauda (fig. 6, *B*) is dark, broad at the base with a rounded tip and normally hairy. The anal plate (fig. 6, *B*) is dark, rounded and has a small but distinct incision or notch in the middle.

The nymphs are slightly paler in color than the mature forms.

WINGED VIVIPAROUS FEMALE—VIRGOGENIA

The winged forms are dark reddish brown with black markings. The length averages 1.9 mm., and the greatest width 1 mm. The head is light or very dark reddish brown. The antennae (fig. 7, *C*) are dusky or black with the greater portion of article III and the basal halves of IV and V pale yellow or amber. They are about three-fourths the length of the body, the measurements of the respective articles being: I 0.1 mm., II 0.07 mm., III 0.44 mm., IV 0.3 mm., V 0.28 mm., VI 0.18 mm. (base 0.13 mm., spur 0.05 mm.), total 1.37 mm. There are from four to eight large and small circular sensoria on article III. Of fourteen antennae examined to ascertain the number of sensoria on article III it was found that but one had 4 sensoria, three had 5, six had 6, two had 7, and two had 8. Articles V and VI have the usual sensoria. The rostrum is amber in color and reaches to the third coxae. The thorax is reddish brown with very dark brown or black muscle lobes. The wings are subhyaline with distinct dusky bordered veins. The venation is shown in the accompanying drawing (fig. 7, *A*). The legs are dark with lighter areas in the middle of the tibiae. The abdomen is reddish brown with one or two rows of dark or black markings near the margins from

which arise short spines. The dark areas increase in size towards the posterior end. The cornicles (fig. 7, *B*), the cauda and the anal plate are much the same as in the apterous form already described.

HOST PLANTS, LOCALITIES, DATES AND COLLECTORS

This species feeds in compact colonies on the bark and very rarely on the leaves of the coast live oak, *Quercus agrifolia* Nee. As already stated apterous forms were first taken by S. H. Essig

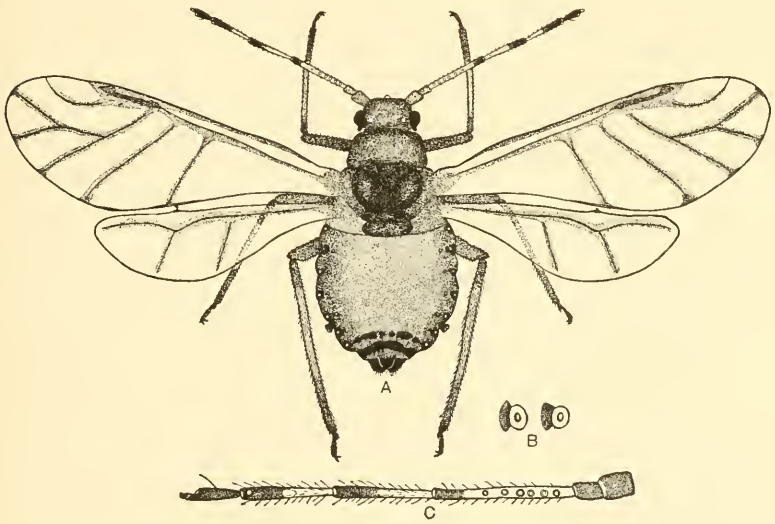


Fig. 7. *Symydobius agrifoliae*, n. sp. Winged viviparous female. *A*, dorsal aspect; *B*, cornicles; *C*, antenna. (Original.)

and the writer in Santa Paula Cañon, near Santa Paula, California, on July 21, 1911. Apterous forms as well as winged were also taken by the former collector in the same locality on May 27, 1916, as well as along the Ventura River near Ventura, California, on June 21, 1916.

Symydobius agrifoliae, n. sp. is closely related to *Symydobius albasiphus* Davis, but is at once separated by having a much shorter spur on the sixth antennal article as well as other differences.

Myzus aquilegiae, n. sp.

APTEROUS VIVIPAROUS FEMALE—VIRGOGENIA

The apterous female is very pretty, being of a pinkish or reddish color with a very large dark brown or nearly black irregular blotch on the middle of the back. The body is of medium size, beset with short knobbed hairs and averaging 1.7 mm. in length and 0.7 mm. in width. The antennae (fig. 8, *F*, *G*) arise from definite but short frontal tubercles (fig. 8, *B*),

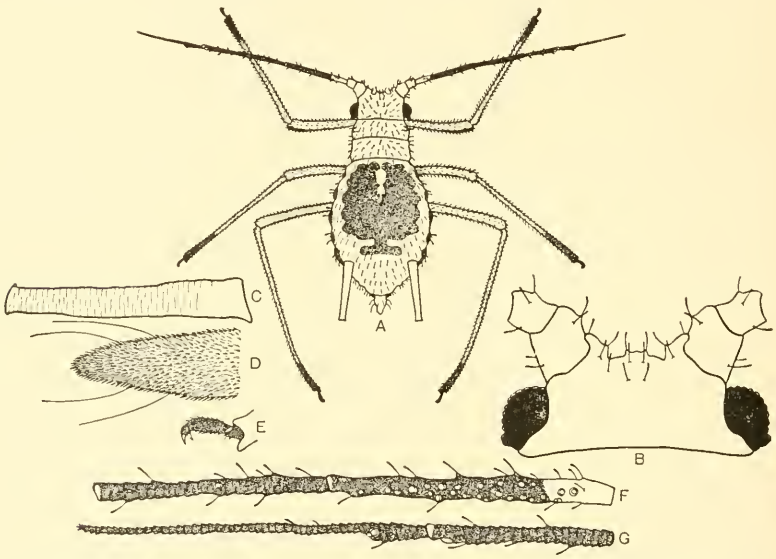


Fig. 8. *Myzus aquilegiae*, n. sp. Apterous viviparous female. *A*, dorsal aspect; *B*, head and frontal tubercles; *C*, cornicle; *D*, cauda; *E*, tarsus; *F–G*, antenna. (Original.)

are slightly longer than the body, dusky throughout excepting the base of article III, imbricated and supporting a number of knobbed hairs. The lengths of the respective articles are: I 0.09 mm., II, 0.07 mm., III 0.5 mm., IV 0.4 mm., V 0.33 mm., VI 0.63 mm. (base 0.1 mm., filament 0.53 mm.), total 2.02 mm. The sensoria are circular and of various sizes. On article III they are distributed throughout the length, but are much more numerous near the middle. On IV there are usually none, but one or two may sometimes occur. The usual number may be found on V and VI. The following tabulation gives the variation found on articles III and IV from eighteen individual females:

Number	Article III	Article IV	Number	Article III	Article IV
1	26	3	10	18	0
	30	4		15	0
2	26	1	11	20	0
	26	0		24	0
3	19	0	12	12	0
	22	1		14	0
4	17	0	13	16	0
	16	0		11	0
5	18	0	14	14	0
	14	0		12	0
6	11	0	15	26	2
	13	0		25	0
7	17	0	16	13	0
	21	1		12	0
8	22	0	17	10	0
	18	0		15	0
9	16	0	18	19	0
	14	0		23	2

The rostrum is pale with dusky tip and reaches slightly beyond the third coxae. The legs are pale yellow with the apices of the tibiae and all of the tarsi dusky. The tarsi (fig. 8, *E*) are very small. The abdomen is yellowish, pinkish or reddish in color with a large brown or black patch on the dorsum and a marginal row of small dark spots on the sides. The large dorsal dark patch may in some cases cover all of the dorsum excepting the extreme base and the area behind the cornicles. The cornicles (fig. 8, *C*) are whitish or yellow, faintly imbricated, nearly cylindrical, with slightly wider base and small flare at the mouth. The length averages 0.47 mm., or about three times the length of the hind tarsi. The cauda (fig. 8, *D*) varies from yellowish to pale pink or reddish, is gradually pointed and about two-thirds as long as the cornicles.

WINGED VIVIPAROUS FEMALE—VIRGOGENIA

The winged viviparous female is yellow or reddish with a number of dark brown or black markings over the body. The length averages 1.4 mm., and the width 0.45 mm. The body is sparsely covered with simple and knobbed curved spines. The head is black and the compound eyes red. The antennae (fig. 9,

F, *G*) arise from small, but distinct frontal tubercles (fig. 9, *B*), are black throughout with few knobbed hairs. The length is greater than that of the body, the respective articles measuring: I 0.07 mm., II 0.06 mm., III 0.52 mm., IV 0.4 mm., V 0.36 mm., VI 0.8 mm. (base 0.12 mm., filament 0.68 mm.), total 2.21 mm. The sensoria are circular, of various sizes and numerous on articles III, IV and V, with the usual ones in the process of VI. The number varies considerably on the different articles, as the following tabulation will show:

Number	Article III	Article IV	Article V	Number	Article III	Article IV	Article V
1	24	0	0	8	34	17	8
	26	1	0		31	18	6
2	30	21	4	9	34	21	5
	36	16	9		37	16	8
3	31	18	5	10	42	23	3
	32	17	9		38	18	4
4	44	23	3	11	34	14	5
	42	23	2		32	16	5
5	38	19	6	12	24	15	5
	35	23	8		27	14	3
6	35	19	5	13	26	11	6
	29	15	3		23	16	6
7	33	16	3	14	38	14	9
	34	19	5		34	18	5

The rostrum is pale with the apical half dusky and reaches slightly beyond the third coxae. The thorax is black with reddish areas at the sides and between the segments. The wings are normal in length with brownish veins and stigma. The venation is shown in the accompanying drawing (fig. 9, *A*). The legs are nearly all black, excepting the middle of the tibiae and the bases of the femora. As in the apterous form the tarsi (fig. 9, *E*) are exceptionally small. The abdomen is reddish with small irregular dark markings on the sides and dorsum. The cornicles (fig. 9, *C*) vary from pale dusky to black, slightly imbricated, cylindrical with a slightly flaring mouth. The length is 0.32 mm., or about three times the length of the hind tarsi. The cauda (fig. 9, *D*) is yellow or reddish and about two-thirds the length of the cornicles.

HOST PLANTS, LOCALITY, DATES AND COLLECTOR

A native columbine, *Aquilegia truncata* F. & M., cultivated in the botanical garden on the campus, appears to be the preferred food plant, though a few specimens were found throughout the season on a nearby species, *A. chrysantha* Gray. The small tender shoots and buds are invariably infested and often the plants are considerably injured by the attacks. The species passes the entire year on the columbine, going as far down

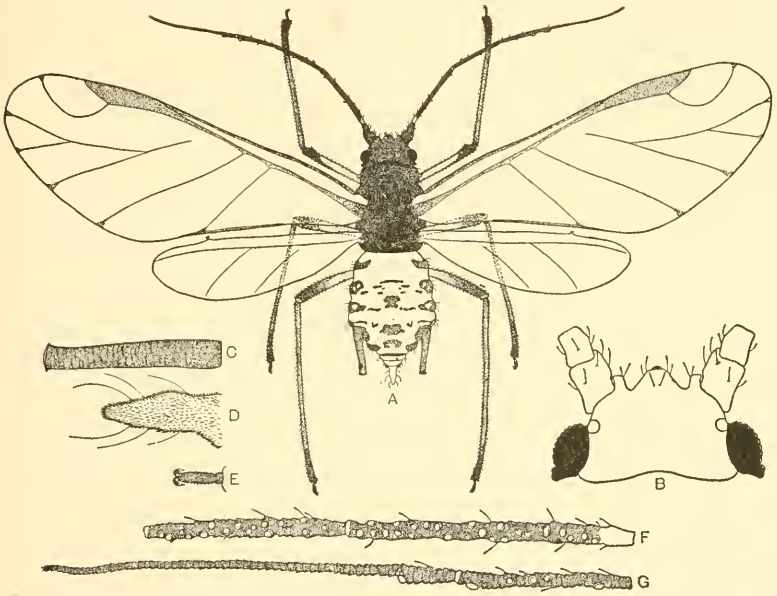


Fig. 9. *Myzus aquilegiae*, n. sp. Winged viviparous female. *A*, dorsal aspect; *B*, head showing frontal tubercles; *C*, cornicle; *D*, cauda; *E*, tarsus; *F G*, antenna. (Original.)

around the crown as possible during the winter. The specimens described were collected by the writer on June 27 and July 3, 1916. It was first noticed by the writer in 1914.

G. O. Shinji, a student, tells me that he has taken this species on a wild columbine in Marin County, but I have not seen his material to verify the same.

Aphis cari, n. sp.

A small plant louse occurring in compact colonies on the stems of the common sweet or wild anise, *Carum kelloggii* Gray,

was of considerable interest to me when first taken because of the characteristic and beautiful coloring. A few specimens were also taken on *Angelica tomentosa* Wats, which led me to believe that the species might be *Aphis angelicae* Koch, reported as occurring in this state by H. F. Wilson,[6] but a microscopic examination at once proved it to be widely different from the species described by Wilson. Not being able to place it in any published description I have decided to describe it as new and to name it after the genus of what appears to be the favorite host plant.

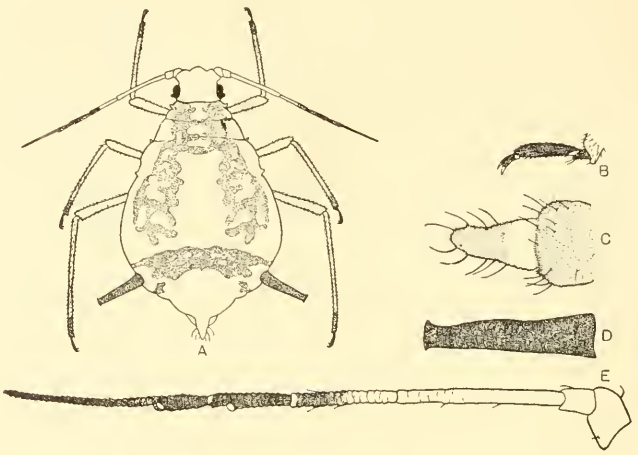


Fig. 10. *Aphis cari*, n. sp. Apterous viviparous female. *A*, dorsal aspect; *B*, tarsus; *C*, cauda; *D*, cornicle; *E*, antenna. (Original.)

APTEROUS VIVIPAROUS FEMALE—VIRGOGENIA

The typical apterous viviparous female is transparently white, yellow or pale yellowish green with very noticeable darker green markings on the dorsum and particularly a distinct transverse patch between the bases of the cornicles. The form is robust, the length averaging 1.7 mm. and the width 1.2 mm. The head is usually pale whitish, yellow or pale yellowish green without darker markings. The antennae (fig. 10, *E*) are whitish or yellow throughout the basal half, the remainder being dusky or black. Most of the articles are distinctly imbricated. The length is about three-fourths that of the body, the lengths of the respective articles being: I 0.06 mm., II 0.04 mm., III 0.32 mm.,

[6] Jour. Econ. Ent., vol. 2, pp. 348–349, Oct., 1909.

IV 0.21 mm., V 0.16 mm., VI 0.36 mm. (base 0.09 mm., filament 0.27 mm.), total 1.15 mm. The usual sensoria occur on articles V and VI with none on III. The rostrum is pale, transparently white and reaches to the third coxae. The prothorax has a large lateral tubercle at the base and on each side of the body a tubercle is located at the unions of the prothorax and mesothorax and the metathorax and abdomen. The legs are normal in length, transparently white with the tips of the tibiae and the tarsi dusky. The cornicles (fig. 10, *D*) are dusky or black, somewhat wider at the base with a medium-sized lip at the mouth, imbricated and

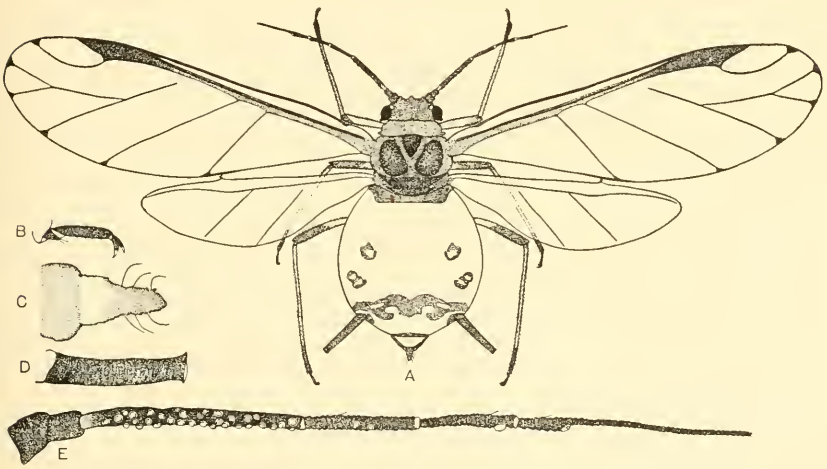


Fig. 11. *Aphis cari*, n. sp. Winged viviparous female. *A*, dorsal aspect; *B*, tarsus; *C*, cauda; *D*, cornicle; *E*, antenna. (Original.)

nearly twice as long as the hind tarsi (fig. 10, *B*), the length being 0.33 mm. and the width at the base 0.09 mm. The cauda (fig. 10, *C*) is dusky, nearly as long as the cornicles, rather slender, with a distinctly wider base for about two-thirds the length when viewed dorsally or ventrally.

WINGED VIVIPAROUS FEMALE—VIRGOGENIA

The winged viviparous female is pale yellowish or greenish with dark green or black head, antennae, thorax, cornicles, apices of the femora, and tibiae and all of the tarsi. The length averages 1.7 mm. and the width 1 mm. The antennae (fig. 11, *E*) are relatively short, reaching only slightly beyond the middle of the abdomen. They are dusky or black throughout and imbri-

cated excepting the basal fourth. The lengths of the respective articles are: I 0.07 mm., II 0.06 mm., III 0.43 mm., IV 0.21 mm., V 0.18 mm., VI 0.41 mm. (base 0.09 mm., filament 0.32 mm.), total 1.36 mm. Article III is covered the entire length with numerous circular sensoria of different sizes. The number varies considerably, from fifteen to fifty, the average being about thirty-five. On article IV of a great many individuals there are no sensoria, while on a few the number varies from one to four. There are the normal number on V and VI. The venation is shown in the accompanying drawing (fig. 11, *A*). The rostrum is dusky and reaches slightly beyond the third coxae. The prothorax has a distinct lateral tubercle on each side of the base. The legs are transparently white or yellow with the apices of the femora and tibiae and all of the tarsi dark. The abdomen is yellow or pale yellowish green with a few darker green markings on the dorsum, and a distinct narrow transverse patch between the cornicles, already referred to. The cornicles (fig. 11, *D*) are nearly cylindrical or with the base somewhat wider than the mouth. They are black or very dark in color, imbricated and about twice the length of the hind tarsi (fig. 11, *B*), the length being 0.25 mm. The cauda (fig. 11, *C*) is much the same as that of the apterous female.

The nymphs vary from pale yellow to faintly yellowish-green with few or no darker markings.

HOST PLANTS, LOCALITIES, DATES AND COLLECTORS

As previously stated this species was first taken on the native wild or sweet anise, *Carum kelloggii* Gray, which appears to be the normal food plant. The insects feed in compact colonies on the stems, usually near a fork and sometimes entirely out of sight beneath the sheath of a leaf petiole. The above infested plants were apparently growing in a wild state along a creek bed in Napa County near the town of Rutherford. Collected by the writer on June 21, 1916.

The second lot, consisting of but few specimens, was taken on the leaves of *Angelica tomentosa* Wats, another native plant growing in the botanical garden on the campus in close proximity to a clump of the wild or sweet anise, which at the particular time showed no infestation. The specimens were collected by the writer on June 27, 1916.

On June 27, 1916, Professor C. W. Woodworth took at St. Helena a plant louse from *Carum kelloggii* Gray which appears to be the same species. The apterous viviparous females, which were the only forms collected, agree in size, shape and coloration, but the cauda is wider and the antennal joints somewhat shorter.

NOTES ON OTHER APHIDIDAE

Chiefly from the Campus of the University of California, Berkeley, California

Phyllaphis, sp. (fig. 12.) A pale greenish or yellow plant louse which secretes over the body a quantity of white woolly material and which has commonly been called *Phyllaphis querci* Fitch. It is not that species, as has been pointed out by Baker[7] and is probably not *P. quercifoliae* Gillette.[8] It occurs in considerable numbers on the undersides of the leaves of the coast live oak, *Quercus agrifolia* Nee., on the campus, but only apterous forms have been secured here thus far. Specimens were received from Altadena, California, August 14, 1916, taken on the same host plant. What also appears to be the same thing was collected at Rutherford, California, June 21, 1916, on valley oak, *Quercus lobata* Nee. The lot included one winged male which agrees very well with Gillette's description of the same sex of *P. quercifoliae*.

Phyllaphis fagi (Linn.). A small yellow and black species densely covered with white woolly material was taken on the undersides of the leaves of *Fagus tricolor* in a lath-house at Oakland, California, July 25, 1916. All forms appear somewhat smaller than specimens which I have under that name in my collection.

Drepanosiphum platanoides (Schrank). A large dark or pale green species infesting the leaves of Norway maple, *Acer platanoides* Linn., and silver maple, *A. saccharinum* Linn., in Berkeley, and neighboring cities. The dark sexual forms are abundant in September and October. This is the commonest species attacking the maple here.

Drepanaphis acerifolii (Thomas). This very pretty insect is gray and black in the winged form and pale yellow in the

[7] Baker, A. C., Ent. News, vol. 27, p. 361, 1916.

[8] Gillette, C. P., Ent. News, vol. 25, pp. 274–275, 1914.

apterous, and is at once separated from other closely related species by the large dark tubercles on the back of the winged forms. It has been taken during several successive years and becomes abundant in a few localities. The sexual forms were taken September 16, 1916. The Norway maple, *Acer platanoides* Linn. and the silver maple, *A. saccharinum* Linn. are attacked.

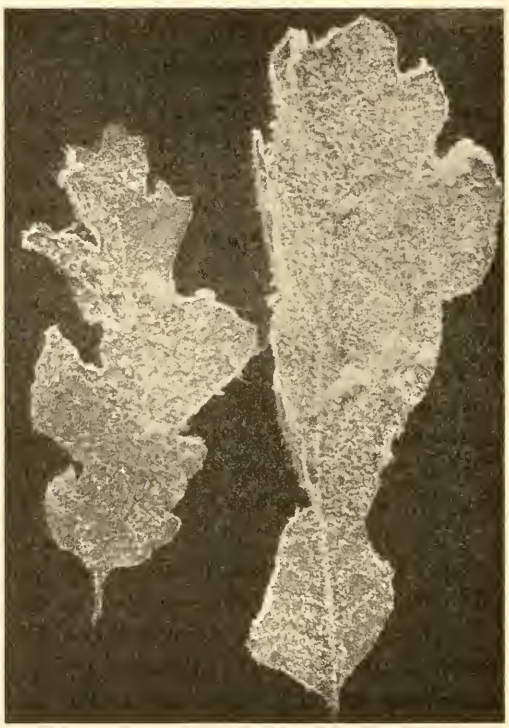


Fig. 12. *Phyllaphis*, sp. Colonies on the undersides of the leaves of the valley oak, *Quercus lobata* Nee. The bodies are entirely covered with the white woolly material. Rutherford, Cal., June 21, 1916. (Original.)

Calaphis betulaecolens (Fitch). A large green species common in certain restricted areas on the European white birch, *Betula alba* Linn. Collected on the campus June 5, 1916.

Euceraphis betulae (Linn.). A large green and black plant louse which is commonest on the birches in this section. It occurs on the leaves of the European white birch, *Betula alba* Linn., the cut-leaved birch, *B. populifolia laciniata* Hort., and the paper or

canoe birch, *B. papyrifera* Marsh. The species is abundant throughout the year and causes much smutting of the trees.

Eucallipterus flavus Davidson. A pale green species of large size taken in few numbers on the old leaves and in abundance on the tender shoots of the white alder, *Alnus rhombifolia* Nutt., in Wildcat Cañon, near Berkeley, California, May 10, 1916.

Eucallipterus tiliae (Linn.). A beautiful yellow and black

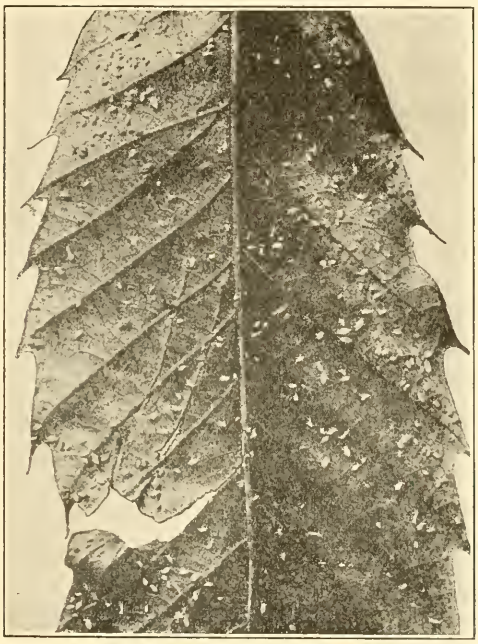


Fig. 13. *Myzocallis castaneae* (Fitch). On leaf of a chestnut tree, Campus, Oct. 10, 1916. (Original.)

species with black clouded wings which often becomes very abundant on linden trees, producing quantities of honey-dew and giving the trees a black and offensive appearance. Specimens were taken on the American linden, *Tilia americana* Linn., in Golden Gate Park, San Francisco, California, May 25, 1916, and on white or silver linden, *T. tomentosa* Moench, Berkeley, California, June 17, 1916.

Myzocallis castaneae (Fitch) (fig. 13). A small yellow aphid which has been called this species occurs on hickory and chestnut on the campus and is often in large enough numbers to

cause a general smutting of the trees. Viviparous females occur throughout the spring and summer. Sexual forms were taken on October 10, 1914.

Myzocallis coryli (Goetze). This very small pale yellow species occurs in great numbers on the undersides of the leaves of an introduced hazel or filbert, *Corylus maxima* Mill., growing in the botanical gardens on the campus. The insects secrete quantities of honey-dew and cause severe smutting of the foliage. Collected in great numbers on June 28, 1916, when apparently at its maximum development.

Myzocallis pasaniae Davidson. A yellow species of median size infesting the undersides of the leaves of the tanbark oak, *Pasania densiflora* Oerst., growing on the Campus, June 27, 1916.

Myzocallis quercus (Kalt). This small species varies in color from pale yellow to light green and has four rather conspicuous dark tubercles on the dorsal base of the abdomen. It generally infests a number of deciduous oaks on the campus, including the English oak, *Quercus robur* Linn. Collected October 10, 1914, and June 20, 1916. It was also taken on what appears to be the same oak in Golden Gate Park, San Francisco, California, May 25, 1916. The species was questioned for some years but was recently verified for W. M. Davidson by P. van der Goot and for the author by A. C. Baker. (The recently published paper in *The Entomological News*, vol. 28, no. 2, Feb., 1917, pp. 62–63, plate 7, by G. O. Shinji, a student here, has added to the confusion. He described two species, *Myzocallis essigi* and *M. woodworthi* from *M. quercus* (Kalt.). *M. essigi* is the common forms of *M. quercus* and *M. woodworthi* is the male of the same thing. All of the specimens were taken from the tree from which my specimens of *M. quercus* were taken. Had Shinji submitted his paper to some member of the entomological department as should have been done such an error could have been avoided. Mr. A. C. Baker examined the type slides also and agrees with my determinations. It might be stated here that there are a number of different species on the type slides and it was necessary to have Mr. Shinji designate the type described in each case.—March 1, 1917.)

Myzocallis ulmifolii (Monell). A bright yellow species occurring on the leaves of English elm, *Ulmus campestris* Smith, and other elms at Berkeley, California, September 20, 1916, and at Sacramento, California, July, 1914.

Chromaphis juglandicola (Kalt.). The common small yellow aphid occurring in great numbers on the undersides of the leaves of the cultivated English walnut, *Juglans regia* Linn. It is abundant throughout the state where this tree is grown and often

Fig. 14. *Pterocomma floceulosa* (Weed). Three apterous viviparous females almost hid by the white flocculence. On arroyo willow, *Salix lasiolepis* Benth. Berkeley, Cal., June 15, 1916. (Original.)

causes much smutting of the foliage. So far I have never taken it from any other species of the walnut[9].

Thomasia salicicola Essig. A very dark species with a median dorsal longitudinal line on the backs of the apterous females

[9] A common yellow species occurring on the leaves of various black walnuts in this region does not seem to agree with the descriptions of *Callipterus caryae* (Monell) or *Monellia caryella* (Fitch), however it has been determined as the latter by A. C. Baker.

occurring in very dense colonies on the terminal shoots of willows. Taken on the campus, June 13, 1916, infesting the arroyo willow, *Salix lasiolepis* Benth.

Pterocomma flocculosa (Weed) (figs. 14 and 15). Taken at

Fig. 15. *Pterocomma flocculosa* (Weed). Eggs laid on arroyo willow, *Salix lasiolepis* Benth., Sacramento, Cal., Dec. 14, 1916. (Original. Photo by Div. Sci. Illust., Univ. Calif.)

Berkeley on arroyo willow, *Salix lasiolepis* Benth., June 15, 1916, at Rutherford, California, June 21, 1916, on the same willow, and at Sacramento, California, December 14, 1916, on the same plant. In the latter case the oviparous females were depositing quantities of eggs which were partially concealed by white

woolly material. This bark feeder is at once distinguished by the partial covering of thin white wool and the bright orange cornicles.

Pterocomma populifoliae (Fitch). This dark gray and brown species occurs plentifully on *Salix*, spp., on the campus, March 29, 1916. Lacks the cottony covering of the preceding species.

Tuberolachnus viminalis (Fonsc.) (fig. 16). Our largest species occurring on willow and easily recognized by the gray color and the large black tubercle on the back between the cornicles. Abundant on the trunks and branches of various willows and feeding in large compact colonies. Taken on yellow willow, *Salix lasiandra* Benth., red willow, *S. laevigata* Bebb.,

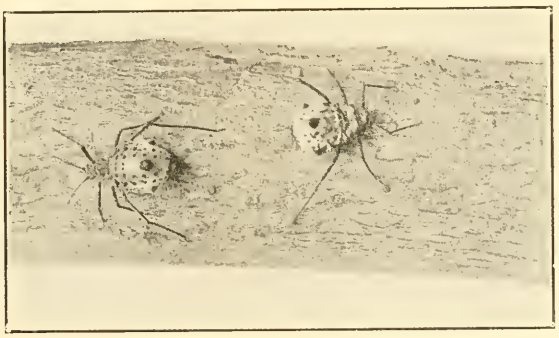


Fig. 16. *Tuberolachnus viminalis* (Fonsc.). Apterous viviparous females on longleaf willow, *Salix longifolia* Muhl. Berkeley, Cal., June 10, 1916. (Original.)

longleaf willow, *S. longifolia* Muhl., and arroyo willow, *S. lasiolepis* Benth., on the campus and at Berkeley and on the arroyo willow at Rutherford, California, June 21, 1916.

Lachnus pini-radiatae Davidson. This very dark green species is partially covered with a thin whitish woolly secretion and usually feeds in colonies in rows on the pine needles. Taken on the campus in small numbers on yellow pine, *Pinus ponderosa* Dougl., January 1 and March 11, 1915.

Lachnus tujafilinus Del Guercio. A robust brown and grayish species occurring in dense colonies on the twigs of common arborvitae, *Thuya occidentalis* Linn. Received from Chas. B. Weeks, Red Bluff, California, February 8, 1916.

Nectarosiphum rubicola (Oestlund). A large normally green species occurring in colonies on the undersides of the leaves of

the thimble berry, *Rubus parviflorus* Nutt., on the campus, March 29, 1916. At this date there were also a number of young pink forms not observed during the summer. The insects were especially abundant on the thimble berry in Wildcat Cañon near Berkeley, May 24, 1916. The species is easily recognized by the dusty tip of the primary wings.

Macrosiphum albifrons Essig. A large green species covered with a white pulverulence, which feeds upon various lupines, including *Lupinus latifolius* Agarth. and tree lupine, *L. arboreus* Sims., on the campus, March 29, 1916.

Macrosiphum californicum (Clarke) (syn. *M. laevigatae* Essig). A bright green, large very slender species infesting the terminal shoots of the young growth of various willows, especially the arroyo willow, *Salix lasiolepis* Benth., and the yellow willow, *S. lasiandra* Benth. Occurs on the campus throughout the summer and collected June 1, 13, and July 26, 1916. Also taken on the arroyo willow at Rutherford, California, June 21, 1916.

Macrosiphum granarium (Kirby). A large green and black aphid common on various grasses and taken as follows: oats, campus, March 10, 1916, and at Martinez, California, June 12, 1916; on meadow fox-tail, *Alopecurus pratensis* Linn., campus, April 25, 1916; on *Ampelodesma tenax* Link, and wild rye, *Elymus*, sp., campus, June 27, 1916. In case of the last two plants the flower heads were entirely covered with the insects.

Macrosiphum lactucae (Schrank). A large bright green and black species common on the tender terminal shoots of chicory, *Chicorium intybus* Linn., growing in an apparent wild state at Rutherford, California, June 21, 1916.

Macrosiphum ludovicianae (Oestlund). A large green species with the bodies of many covered with a thin white pulverulence. Collected on the campus March 10, 1916, and at Rutherford, California, June 21, 1916. In both cases the terminal tips of the common wormwood or California mugwort, *Artemisia heterophylla* Nutt., were infested..

Macrosiphum rhamni (Clarke). This large species is green with a noticeable large reddish, nearly circular blotch in the middle of the dorsum at the union of the thorax and abdomen. This coloration is internal and disappears with mounting. Apterous and winged forms were specially abundant on the leaves of coffee berry, *Rhamus californicus* Esch., and less common on cascara sagrada, *R. purshiana* DC., on the campus during

1916. Taken on the former, July 5, when it appeared to have reached its maximum development, and on the latter, June 29, 1916.

Macrosiphum rosae (Linn.). This is the common large green and reddish louse so common in the rose gardens of the state. Besides being found on all varieties of roses, this species has also been taken on the stems of the heads of the fuller's teasel, *Dipsacus fullonum* Linn., June 7, 1916, the red valerian or Jupiter's beard, *Centranthus ruber* DC., June 23, 1916, at Berkeley, California, and on wild rose, *Rosa californica* C. & S., at Rutherford, California, June 21, 1916.

Macrosiphum solanifolii (Ashmead). A large pale yellow or green aphid attacking a large number of plants. On the campus it was collected on yarrow, *Achillea millefolium* Linn., March 29, 1916, and on tobira or Japanese pittosporum, *Pittosporum tobira* Ait., July 5, 1916. Also taken on the tender shoots of the American, white or water elm, *Ulmus americanus* Linn., in Golden Gate Park, San Francisco, California, May 25, 1916.

Macrosiphum stanleyi Wilson. A beautiful large yellow and black species abundant on the undersides of the leaves of the red elderberry, *Sambucus racemosa callicarpa* Jepson, on the campus throughout the spring, summer and fall months. It was taken in fewer numbers on the tender growth of the blue elderberry, *S. glauca* Nutt., growing along the creek in shady places on the campus, May 15, 1916.

Idiopterus nephrelepidis Davis. A small pitch black species with whitish legs and black clouded areas in the wings. It is becoming of considerable economic importance as a pest to greenhouse and household ferns. During the past year it has been observed to be quite injurious to the common and improved Boston ferns, *Nephrolepis*, spp., as well as to the holly fern, *Cyrtomium falcatum* J. Smith.

Amphorophora latysiphon Davidson. A large green and black species with black conspicuously swollen cornicles. Large numbers of apterous and a single winged individual were taken on the crowns at and under the surface of the ground of Shasta daisies, *Chrysanthemum*, sp., Berkeley, California, August 15, 1916, and on the tender opening buds of the common garden cowslip, *Primula*, sp., December 17, 1916, at the same locality.

Amphorophora rubi (Kalt.). A large green aphid attacking the terminal shoots of the cultivated blackberry, *Rubus*, sp., and

wild blackberry, *R. vitifolius* C. & S., Berkeley, California, March 25, and June 6, 1916.

Toxoptera aurantiae Fonsc. A small black species attacking the leaves and terminal shoots of lemon, Martinez, California, June 12, 1916, and camellia, *Camellia japonica* Linn., in a lathhouse at Oakland, California, July 25, 1916.

Fig. 17. *Phorodon humuli* (Schrank) on the underside of a plum leaf, Berkeley, Cal., April 10, 1916. (Original. Photo by Div. Sci. Illust., Univ. Calif.)

Phorodon humuli (Schrank) (fig. 17). A pale yellowish green aphid which during the past season was first observed on the tender leaves of plum on the campus, April 7, 1916. At that time only apterous females occurred, but on April 14 a great many winged migrants were present and by April 25 practically all were winged. The species was also abundant on plum in Golden Gate Park, San Francisco, California, May 25, 1916. By the middle of the summer all had become winged and left the plum trees. Later in September specimens were taken on hops.

Rhopalosiphum arbuti Davidson. This is a fairly large green and black species occurring commonly on madrone, *Arbutus menzesii* Pursh. on the campus. Other trees infested are: the strawberry tree *Arbutus unedo* Linn., campus, May 18, 1916; the tender tips of the mountain holly or Christmas berry, *Photinia arbutifolia* Lindl., campus, May 15, 1916. It was also collected on the strawberry tree in Golden Gate Park, San Francisco, California, June 5, 1916. E. P. Van Duzee of the California Academy of Sciences collected it on the common manzanita, *Arctostaphylos manzanita* Parry, at Hoberg's Resort, Lake County, California, August 2, 1916. This is undoubtedly *Rhophalosiphum nervatum* Gillette.

Rhopalosiphum howardii Wilson. A medium-sized, shiny dark red or almost black species associated with *Macrosiphum*

granarium (Kirby) on the leaves, stems and in the heads of oats at Martinez, California, June 12, 1916. It was later taken in the heads of barley at Rutherford, California, June 21, 1916. This is very close if not synonymous with *Rhopalosiphum rhois* Monell.

Rhopalosiphum lactucae (Kalt.). A normal-sized green and black aphid first taken by the writer on the common sow thistle, *Sonchus oleraceus* Linn., at Santa Paula, California, April 3, 1916, and erroneously labeled *Rhopalosiphum persicae* (Sulzer). Last year it was collected on the same host plant at Berkeley, California, June 28, 1916, and at San José, California, July 14, 1916

Rhopalosiphum nerratum Gillette. A green species smaller than the common rose aphis, *Macrosiphum rosae* (Linn.), and distinguished from it by the darker wing veins and swollen cornicles. Occurs throughout the year and collected, February 20, 1916. (See *R. arbuti* Davidson).

Rhopalosiphum nymphaeae (Linn.) (fig. 18). A large dark-red plant louse covered with a fine white pulverulence or often a shiny dark green form as appears in the late summer. Winged and apterous viviparous females, all pink or dark-red, were first taken on tender twigs of a plum tree on the campus, April 7, 1916, where they occurred in large, compact colonies. The species, the same color phase, was also taken on plum in Golden Gate Park, San Francisco, California, May 25, 1916. By the middle of June none could be found on the plum in either locality, but on June 21, 1916, the dark green and shining phase was very abundant on water plantain, *Alisma plantago* Linn., and pondweed, *Potamogeton natans* Linn., at Rutherford, Cal.

Rhopalosiphum persicae (Sulzer). This is a very common green species with a conspicuous black patch in the middle of the abdomen of the winged form. It is an omnivorous feeder, attacking a very large number of plants. Among those observed during the past year were: *Lavatera assurgentiflora* Kellogg, campus, June 27, 1916; *Clarkia elegans* Dougl., campus, March 29, 1916; *Pentstemon spectabilis* Thurb., campus, March 29, 1916; California laurel or pepperwood, *Umbellularia californica* Nutt., campus, April 16, 1916; nasturtium, Hayward, California, April 19, 1916 (coll. by Roy E. Campbell); tulip tree, *Liriodendron tulipifera* (Linn.), campus, April 24, 1916; tobira or Japanese pittosporum, *Pittosporum tobira* Ait., campus, July 5, 1916;

tarata, *Pittosporum eugenioides* A. Cunn., campus, July 5, 1916; Victorian box, *Pittosporum undulatum* Vent., campus, July 5, 1916; *Baccharis douglasii* DC., Berkeley, California, June 17, 1916, red valerian or Jupiter's beard, *Centranthus ruber* DC.,

FIG. 18. *Rhopalosiphum nymphaeae* (Linn.). Colony on twig of plum. One mature apterous viviparous female and the remainder nymphs. Berkeley, Cal., April 18, 1916. (Original. Photo by Div. Sci. Illust., Univ. Calif.)

Berkeley, California, June 23, 1916; the fullers' teasel, *Dipsacus fullonum* Linn., campus, June 27, 1916, *Escallonia pulverulenta* Pers., campus, June 27, 1916; *Helianthus major* Linn., campus, June 27, 1916, and sunflower, *Helianthus annuus* Linn., Berkeley, California, August 15, 1916.

Fig. 19. *Myzus cerasi* (Fab.) on the underside of a cherry leaf and curled leaves caused by the attacks. Berkeley, Cal., April 25, 1916. (Original. Photo by Div. Sci. Illust., Univ. Calif.)

Rhopalosiphum rhois Monell. A dark green or black shiny aphid occurring abundantly on the tender shoots of the poison oak, *Rhus diversiloba* T. & G., during the spring and early summer, but entirely disappearing by the middle of summer. Often

Fig. 20. *Myzus varians* Davidson. Curled leaves of tender peach shoot caused by this insect. Berkeley, Cal., June 7, 1916.

causes severe curling of the leaves. Campus, July 3, 1916—only a very few were to be found at this date. (See *R. howardii* Wilson).

Myzus cerasi (Fab.) (fig. 19). A shiny black aphis with long cornicles, occurring in large dense colonies on the shoots and

young fruit of cherries and forming large curled pseudogalls on the former. Very common in this district and often the cause of much worry to orchardists. Collected at Berkeley, California, April 25 and August 21, 1916. Disappears soon after the last date.

Myzus circumflexum (Buckton). This is a very pretty yellow or pale green and black species which is a common greenhouse pest infesting maidenhair, asparagus and holly ferns and a great many other plants already listed by other writers. During the past year the species was taken on the tender shoots of the California laurel or pepperwood, *Umbellularia californica* Nutt., campus, April 16, 1916, on the flower heads of *Pentstemon spectabilis* Thurb., campus, March 29, 1916, and on the lower leaves of both of the show lilies, *Lilium elegans grandiflorum* and *L. speciosum rubrum* growing in a lath-house at Oakland, California, July 25, 1916.

Myzus fragaefolii Cockerell. A small pale yellow aphid infesting the undersides of the leaves of the cultivated strawberry and at times causing considerable smutting of the foliage. Taken at Niles, California, June 16, 1916.

Myzus varians Davidson (fig. 20). A pale yellow or green and black species somewhat resembling *Rhopalosiphum persicae* (Sulzer) which occurs in large colonies on the host plants and often causes much smutting of the foliage. Taken throughout the spring and summer on clematis, *Clematis brachiata* Thurb., on the campus and appear to reach their maximum development when collected, June 9th to the 29th, 1916. It was also taken July 7, 1916, at Berkeley infesting the terminal shoots of peach, causing the leaves to curl and become reddened much as if infected with peach curl. Within the pseudogalls thus formed were great numbers of the aphids; one or two trees were severely injured by the attacks.

Pentalonia nigronervosa Coquerel. A very interesting small black species greatly resembling *Idiopterus nephrelepidis* Davis. Specimens were received from Mr. E. M. Ehrhorn, who collected it on ferns at Honolulu, H. T., in March, 1916. This insect does not occur in California, but might be introduced or may have been, and could be easily mistaken for the other species which it resembles. It has previously only been reported on banana.

Hyalopterus arundinis (Fab.) (fig. 21). An average sized, pale green and black species with the bodies usually covered with

quite thick whitish pulverulence and occurring in dense colonies on the leaves of the young growth of prune and plum trees. It was also taken in considerable numbers on apricot trees at Niles, California, July 11, 1916. The Japanese varieties of plums appear to be immune to their attacks as was exemplified last year at Martinez, California, where a few prune trees growing in a thrifty young orchard of Burbank plums were very seriously attacked, while not a single infestation could be found on any of the plum trees. It is also of interest to know that the cracking, usually a cross, at the ends of prunes in the Santa Clara Valley

Fig. 21. *Hyalopterus arundinis* (Fab.) Prunes showing the characteristic splitting at the ends as a result of the presence of this insect on the foliage. Morgan Hill, Cal., July 14, 1916. (Original.)

has been definitely found to be due to the attacks of this insect, according to Horticultural Commissioner Earl Morris, and the annual loss occasioned is sometimes considerable.

Aphis albipes Oestlund (fig. 22). The apterous viviparous females are dark with whitish pulverulence arranged in definite patterns on the back as shown in the illustration. The apterous forms (fundatrix) were taken on the shoots of the snow berry, *Symphoricarpos racemosus* Michx., on the campus, March 25, 1916. Great numbers of both winged and apterous viviparous females were taken from the terminal shoots of the same plant on May 15, 1916. The leaves are often curled in dense irregular masses and form splendid protection for the insects. The species was determined by John J. Davis.

Aphis avenae Fab. A small dark green species abundant on corn, grain and grasses on the campus. Collected March, 1916.

Aphis bakeri Cowen. A small pale yellow or pinkish and black species taken sparingly on the flower heads and at the bases of the leaves of red clover, *Trifolium pratense* Linn..

FIG. 22. *Aphis albipes* Oestlund. Apterous females on the leaf of snow berry, *Symphoricarpos racemosus* Michx. Campus, March 29, 1916. (Original. Photo by Div. Sci. Illust., Univ. Calif.)

campus, June 29, and July 25, 1916. Not abundant here at any season.

Aphis brassicae Linn. (fig. 23). A pale green species covered with whitish pulverulence and feeding in compact colonies on the common cruciferous plants of the state. Especially injurious to cabbage, cauliflower, brussels sprouts, kale, mustard, radish, turnips, etc. Present throughout the year.

Aphis cardui Linn. (fig. 24). A fairly large green and black, shiny aphid. The apterous fundatrix occurred in small colonies on the tips of tender plum suckers on the campus, April 10, 15, 24, 25, 1916. It is very common throughout the summer in great colonies entirely covering all parts of the bull thistle, *Cirsium lanceolatum* Linn.

Aphis ceanothi Clark (syn. *A. ceanothi-hirsuti* Essig). A small dull reddish and black species which becomes very abundant

Fig. 23. *Aphis brassicae* Linn. A winter colony on the leaf of brussels sprouts. Berkeley, Cal., Nov. 6, 1916. (Original. Photo by Div. Sci. Illust., Univ. Calif.)

on various species of *Ceanothus* throughout the state. Taken at Berkeley and on the campus infesting *Ceanothus thrysiflorus* Esch. and soapbush, *Noltea africana* Reichb., June 2, 1916. Also very common on soapbush in Golden Gate Park, San Francisco, California, May 25, 1916.

Aphis gossypii Glover. A small dark green or black aphid usually feeding in dense colonies. Abundant on the creek milkweed, *Asclepias speciosa* Torr., and a few on cascara sagrada, *Rhamnus purshiana* DC., on the campus, July 3 and 5, 1916. Also taken on show lily, *Lilium speciosum rubrum*, Oakland,

California, July 5, 1916; on woolly milkweed, *Asclepias vestita* H. & A., Visalia, California, July 19, 1916, by W. P. Baird, and on honeysuckle, *Lonicera*, sp., and catalpa, *Catalpa*, sp., at St. Helena, California, June 18, 1916, by C. W. Woodworth.

Aphis herderae Kalt.? A small dull black species occurring in compact colonies on English ivy, *Hedera helix* Linn., and a number of other plants is certainly not *Aphis rumicis* Linn., so is provisionally listed as this species. Abundant at Berkeley, California, and collected June 2, 1916.

Aphis helianthi Monell is a pale or dark green species with black markings on the winged form and occurs abundantly on the undersides of the leaves of the common and wild sunflower,

Fig. 24. *Aphis cardui* Linn. Apterous viviparous females taken from plum tree, Campus, April 10, 1916. (Original. Photo by Div. Sci. Illust., Univ. Calif.)

Helianthus annuus Linn. Unrecorded specimens first taken by the writer at Pomona, California, in 1909.

Aphis heraclei Cowen.[10] A medium dark species with greenish or reddish mottlings on the dorsum. Occurs abundantly on the old yellow leaves of *Heracleum mantegazzianum* Sommier & Levier in the botanical garden on the campus, June 9, 1916.

Aphis malifoliae Fitch (syn. *Aphis sorbi* Kalt. for here). A common rosy and black species also slightly covered with a whitish pulverulence. Occurs on the young fruit and curls the leaves of apple. Often a serious orchard pest. Collected at Berkeley, California, April 28, 1916, by E. L. Prizer.

[10] I am indebted to Mr. John J. Davis for the determination of this species and for the information that the specific name is also preoccupied by *Aphis heraclei* Koch, thus necessitating a new name for the above.

Aphis maidis Fitch. A small dark green aphid received from Bend, California, July 6, 1916, seriously infesting milo maize. The common species on corn throughout the state, however, is *Aphis avenae* Fab.

Aphis medicaginis Koch (fig. 25). The adults are shiny black with conspicuous whitish legs. Specimens were taken by the writer at Moorpark, California, August 11, 1911, where they were doing great damage to the foliage and pods of the blackeye bean.

Fig. 25. *Aphis medicaginis* Koch. Nymphs and adults on lemon leaf. Sacramento, Cal., 1913. (Original.)

Vigna catjang Walpers. It was also taken on the leaves of lemon, Capitol Park, Sacramento, California, July, 1913.

Aphis middletonii Thos. A pale green and pulverulent species first taken on the roots of rough pigweed, *Amaranthus retroflexus* Linn., and the roots of asters, Santa Paula, California, October 20, 1911.

Aphis nerii Fonsc. A pretty dark yellow and black species common on the oleander during most of the year and also on milkweed during the summer. On the campus it attacks oleander and is specially abundant during the summer months on the

creek milkweed, *Asclepias speciosa* Torr. At Niles an oleander tree was seriously infested July 28, 1916. It was also taken on woolly milkweed, *A. vestita* H. & A., at Visalia, California, July 27, 1916, by W. P. Baird. This is without doubt the common milkweed species described by Montell as *Aphis lutescens* and occurs generally throughout the state.

Aphis oenotherae Oestlund. A small dark green, somewhat pulverulent species occurring in large numbers among the buds and on the flower heads of the evening primrose. Taken on *Oenothera biennis* Linn. on the campus, June 7, 1916, and on the common evening primrose, *O. grandiflora* Ait., and on *Epilobium adenocaulon occidentale* Trelease in Golden Gate Park, San Francisco, California, May 25, 1916.

Aphis persicae-niger Smith. A small shiny black species often abundant on the tender shoots of peach trees. During the past few years it has been received from a number of localities as follows: Peach, Berkeley, California, April 29, 1915; peach, Dinuba, California, April 30, 1915; peach, Yuba City, California, March 25, 1916 (H. P. Stabler); peach, Fresno, California, May 10, 1916; peach, Ventura, California, July 17, 1916 (S. H. Essig). In the latter case the infestation was severe and much of the fruit was also infested. This insect, though distributed throughout much of the state, has never become a serious orchard pest and only abundant on rare occasions.

Aphis pomi DeGeer. This small green and black aphid is a serious pest to a number of valuable ornamental trees in this section, notably the English hawthorn, *Crataegus oxyacantha* Linn. At Berkeley it has also been taken on the following: *Crataegus* spp., laurestinus, *Viburnum tinus* Linn., tarata, *Pittosporum eugenioides* A. Cunn., tawhiwhi, *P. tenuifolium* Gaertn., *Cotoneaster franchetii* Bois., apple and pear, as well as a number of other undetermined plants. The foliage is covered with honey-dew and soon collects dust or becomes covered with the black smut fungus so as to assume a most undesirable appearance.

Aphis rumicis Linn. A dull black species occurring in dense colonies and generally confused with another species which I am calling *Aphis hederae* Kalt. What, according to Davis, is true *A. rumicis* has been taken at Berkeley, California, on the Western dock, *Rumex occidentalis* Wats, April 13, 1916, and on other species of *Rumex* and on the common garden poppy, *Papaver*, sp., June 15, 1916.

Aphis salicicola (Thomas). A pale green species with bright orange-colored males. Very abundant on the tender tips of the arroyo willow, *Salix lasiolepis* Benth., Rutherford, California, June 21, 1916. The species occurred on the same plant throughout the summer and fall at Berkeley and on September 20, 1916, the sexual males and females were also abundant and mating freely.

Aphis sambucifoliae Fitch. The winged and apterous viviparous females are dull black while the sexuparae are amber or dull brownish. The former occur throughout the summer on the blue elderberry, *Sambucus glauca* Nutt. The sexuparae were taken in few numbers on the leaves of the red elderberry, *S. racemosa callicarpa* Jepson, on the campus, September 21, 1916.

Myzaphis abietina (Walker). A very small dark green aphid common on the smaller branches of the Norway spruce, *Picea excelsa* Link, in Golden Gate Park, San Francisco, California, May 25, 1916.

Myzaphis rosarum (Kalt.). A small dark green species often very abundant on the leaves of roses and usually the most serious rose pest, causing severe smutting of the foliage. Taken at Berkeley, California, June 16, 1916, and throughout the summer and fall.

Siphocoryne capreae (Fab.). The apterous forms are pale green and the winged forms pale green and black. Common here on willows, including the arroyo willow, *Salix lasiolepis* Benth., campus, June 13, 1916. Also abundant on the wild or sweet anise, *Carum kelloggii* Gray, at St. Helena, California, June 18, 1916 (C. W. Woodworth) and at Berkeley, California, June 20, 1916. It is the commonest aphid attacking the latter.

Siphocoryne xylostei Schrank. A dull green species often with thin coating of whitish pulverulence. Common on the tender shoots of the honeysuckle, *Lonicera*, spp. Taken at Berkeley, California, July 20, 1916, by Miss A. Williamson.

Liosomaphis berberidis (Kalt.) A small yellow or pale green aphid often very abundant on various species of the barberry and causing considerable smutting. Taken on *Berberis vulgaris* Linn., Golden Gate Park, San Francisco, California, June 5, 1916; on *Berberis*, sp., campus, June 7, 1916, and on *B. vulgaris* Linn., Niles, California, September 30, 1916.

Cerataphis lataniae (Boisduval) (fig. 26). This is a very interesting plant louse and more often taken for a scale insect or

the immature form of a white fly than for an aphid. The young apterous viviparous females are dark or pale brown and when mature acquire a white fringe around the margin as shown in the illustration (fig. 26). The winged forms are dull brownish or blackish in color. The species occurs in greenhouses through-

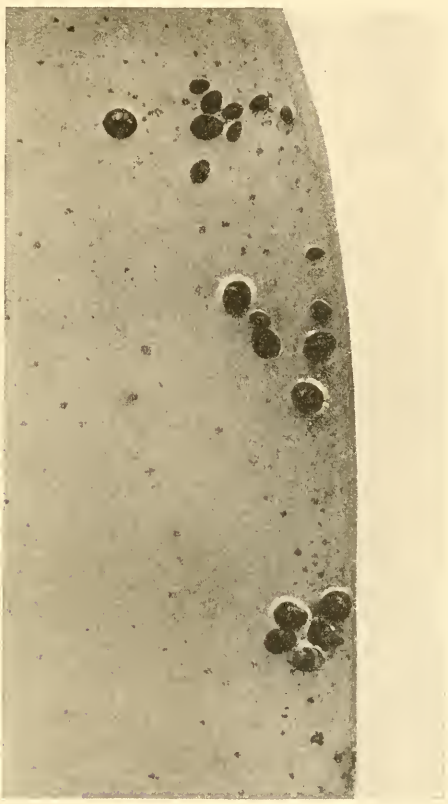


Fig. 26. *Cerataphis lataniae* (Boisduval). Apterous viviparous females on leaf of orchid. Oakland, Cal., July 25, 1916. (Original.)

out this district and sometimes becomes a pest to orchids. Taken on orchids, Oakland, California, July 25, 1916.

Pemphigus populitransversus Riley (figs. 27 and 28). The fundatrix is pale amber or yellowish with tufts of white cottony material arranged in rows on the dorsum. The virgogeniae are black with more or less cottony material at the posterior end of

Fig. 27. *Pemphigus populitransversus* Riley. Galls formed on the leaf petioles of poplar. Berkeley, Cal., Aug. 17, 1916. (Original.)

Fig. 28. *Pemphigus populitransversus* Riley. Stem-mother or fundatrix, and virgogeniae. Campus, Aug. 17, 1916. (Original.)

the abdomen. Forms large galls on the leaf petioles, near the leaves, of poplar. Campus, August 15, 1916.

Eriosoma, sp.? (fig. 29). An undetermined species designated by the common term Wilson's bonnet gall-louse. by Patch.

Fig. 29. *Eriosoma*, sp. Large pseudogall produced on the leaf of English elm, *Ulmus campestris* Smith. Berkeley, Cal., July 8, 1916. (Original.)

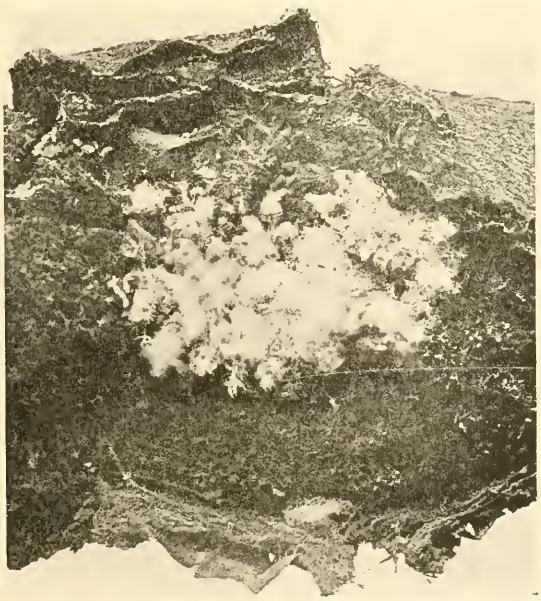


Fig. 30. *Eriosoma lanigera* (Hausm.) Colony of the woolly apple aphis on apple. (Author's illust., Ben. & Inj. Ins. Cal.)

The winged forms are dark and often very numerous in large pseudogalls on the leaves of the English elm, *Ulmus campestris* Smith, at Berkeley, California, July 8, and Hayward, California, July 14, 1916.

Eriosoma lanigera (Hausm.) (fig. 30). A dull reddish species with the bodies entirely covered with long white woolly material giving rise to the common name woolly aphis. A very common species throughout the state on apple and rarely on pears. Sexuparae begin to appear the last of September on the campus, but so far I have not succeeded in taking the sexuales.

Chermes cooleyi Gillette. A very small pinkish or dark, nearly globular plant louse occurring on the needles of various conifers and usually covered with white cottony material and appearing as small white specks on the trees. Sometimes very abundant and injurious. Taken on the campus on Monterey pine and other conifers, March 29, 1916.

Transmitted January 8, 1917.

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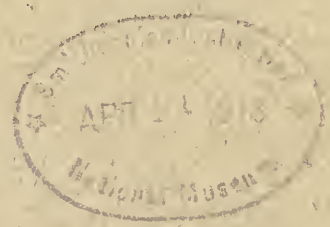
TECHNICAL BULLETINS
COLLEGE OF AGRICULTURE, AGRICULTURAL EXPERIMENT STATION
ENTOMOLOGY
Vol. 1, No. 8, pp. 347-367 March 28, 1918

NEW GENERA AND SPECIES OF ENCYRTINAE FROM CALIFORNIA PARASITIC IN MEALYBUGS (HYMENOPTERA)

BY
P. H. TIMBERLAKE



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NEW GENERA AND SPECIES OF ENCYRTINAE FROM CALIFORNIA PARASITIC IN MEALYBUGS (HYMENOPTERA)

BY
P. H. TIMBERLAKE
Hawaiian Sugar Planters' Experiment Station

The material which forms the basis of this paper has been assembled during the last three or four years, mainly through the efforts of Mr. C. P. Clausen while engaged in a study of *Pseudococcus* and related genera in California. In all, three new genera and six new species are described, the types of which will be deposited ultimately in the United States National Museum. Notes on two foreign or introduced species under *Tanaomastix* are included to complete the generic conception.

Tribe MIRINI

Acerophagus[1] Emily Smith

Of the three species included in the material two are new and all belong to the *A. texanus* group, the five species of which now known may be separated as follows:

FEMALES

1. Wings without a conspicuous cross band 2
   Wings with a smoky band across the disk ..... **A. fasciipennis**, n. sp.
2. Frontovertex about one-third to three-fourths longer than wide 3
   Frontovertex about twice as long as wide, the ocelli in an angle of about 85° ..... **A. notativentris** (Girault)

[1] For a recent revision of this genus see Proc. U. S. Nat. Mus., vol. 50, pp. 574–79. The antennal club of *A. texanus* (Howard), represented as solid in figure 52, plate 31 (*loc. cit.*), in reality is composed of three closely fused joints except in the male.

3. Ocelli small, the posterior pair their own diameter from eye-margin, coloration pale 4
   Ocelli large, the posterior pair close to eye-margin, coloration vivid orange yellow ..... **A. texanus** (Howard)
4. Frontovertex about three-fourths longer than wide, the ocelli in a right angle, coloration chrome lemon yellow ..... **A. pallidus**, n. sp.
   Frontovertex wider, about one-half longer than wide, the ocelli in slightly more than a right angle, coloration pale cadmium yellow ..... **A. gutierreziae** Timberlake

Males

1. Wings hyaline throughout 2
   Wings with a smoky band across the disk ..... **A. fasciipennis**, n. sp.
2. Coloration pale yellow, the abdomen usually more vivid than thorax 3
   Coloration orange yellow, the abdomen concolorous ..... **A. texanus** (Howard)
3. Abdomen without a dark blotch behind the vibrissae 4
   Abdomen with a conspicuous blackish brown blotch behind the vibrissae ..... **A. notativentris** (Girault)
4. Thorax and abdomen pale cadmium yellow ..... **A. gutierreziae** Timberlake
   Thorax gamboge yellow, the abdomen more orange yellow especially at apex and with two dusky transverse bands across the middle ..... **A. pallidus**, n. sp.

Acerophagus fasciipennis, n. sp.

FEMALE

Frontovertex about one-half longer than wide; the ocelli in a right-angled triangle, the median one situated considerably nearer the occipital margin than in *A. gutierreziae*, or very noticeably behind the center of the frontovertex, the posterior pair less than their own diameter from the eye-margin and about twice as far removed from the occipital margin; eyes not pubescent; antennae practically as in the other species of the group, except that the scape and club are proportionately considerably shorter (see table of measurements below); wings nearly uniformly ciliated, the speculum[2] extremely narrow above or practically obliterated, abruptly widening below and connecting with a branch of the hairless streak on the posterior margin; ovipositor slightly longer than in *A. gutierreziae*, or about two-fifths the length of abdomen, its sheaths pubescent. Length, exclusive of ovipositor, 0.75 mm.

Coloration a little paler than in *A. gutierreziae* or more of a clay yellow, the underparts still paler, but the abdomen decidedly brighter or more orange yellow; appendages concolorous with

[2] The term adopted here is one used by Thomson for the oblique hairless streak.

underparts, the antennae except club, however, a little deeper yellow than legs; the ovipositor black at apex; wings with a conspicuous tegumentary smoky band across the disk, its distal margin opposite the end of the stigmal vein and slightly convex, the basal fourth of wing with a brown dot on lower margin at the very base; hind wings also slightly smoky across the middle.

MALE

Frontovertex about one-third longer than wide, the anterior ocellus at the center; otherwise structurally about as in female. The coloration slightly paler, more of a chrome lemon yellow, the abdomen orange yellow, and the wings banded as in the female. Length, 0.8 mm.

Described from one female, one male (type and allotype) reared from early larval stages of *Pseudococcus crawii* (Coquillett), Uplands, California, November, 1914 (C. P. Clausen), Clausen no. 53.

Acerophagus notativentris (Girault)

Fig. 1

Pseudaphycus notativentris Girault, Descrip. Hym. Chalcid. variorum cum Observ., vol. 3, p. 10, Glendale, Md., May, 1917.

FEMALE

Frontovertex nearly twice as long as wide, finely granulose about as in *A. texanus* and minutely punctulate; ocelli forming an angle of about 85°, the anterior one a little behind the center

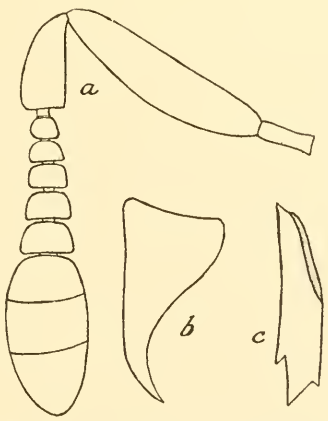

Fig. 1. *Acerophagus notativentris:* A, antenna of female; B, right mandible of female, exterio-dorsal view; C, same, anterior view.

of the frontovertex, the posterior pair about their own diameter from the occipital margin and less than half as far from the eye-margin; face considerably shorter than length of eyes, the scrobes as in the other species; eyes with a rather thick, but fine, short pubescence; funicle joints of antennae (fig. 1, A) proportionately a little wider for their length than in other species; dorsal tooth of mandible (fig. 1, B and C) much smaller and more basal than usually; wings uniformly ciliated, the speculum narrow, not interrupted and reaching nearly to the posterior margin; ovipositor protruded about one-fourth the length of abdomen, its sheaths pubescent. Length, 0.5–0.8 mm., exclusive of ovipositor.

Coloration about cadmium yellow, the face, cheeks, and underparts a little paler; a transverse spot on concealed part of pronotum blackish; the metanotum, but not propodeum, slightly brownish; a spot on sides of abdomen before the vibrissal plates, the vibrissal plates and the margin of the segments in the center of the dorsum of abdomen brown; antennae dusky yellowish, the scape somewhat purer yellow, the club more whitish; coxae and femora yellowish white, the tibiae and tarsi more yellowish with apex of last tarsal joint dusky; exserted portion of ovipositor dusky; wings hyaline, the veins pale yellowish; pubescence of head and thorax dusky.

MALE

Similar to the female in all characters; the frontovertex a trifle wider, the ocelli more nearly in a right angle; the abdomen a little shorter than thorax instead of as long. Coloration somewhat brighter or more of a chrome lemon yellow, the face and underparts more vivid, and the dorsum of abdomen behind the vibrissal plates blackish brown except the sides. Length, 0.42-0.6 mm.

Redescribed from thirteen females, nine males, reared October, 1914, and during the summer of 1915, from a *Pseudococcus* species on grape, Fresno, California (H. S. Smith), California State Insectary no. 675, also compared with Girault's types.

Acerophagus pallidus, n. sp.

Fig. 2

FEMALE

Frontovertex about three-fourths longer than wide, about as closely granulose as in *A. texanus* or almost punctulate; ocelli in a right-angled triangle, the anterior one noticeably behind the

center of the frontovertex, the posterior pair nearly their own diameter from eye-margin and twice as far removed from occipital margin; face a little shorter than length of eyes, the head being a little thinner anteroposteriorly than in *texanus* or *gutierreziae*, the serobes about the same; eyes with a very fine, short, sparse pubescence; antennae (fig. 2, A) about as in other species of the *texanus* group, the pedicel, however, proportionately longer and slenderer, or a little longer than the first four funicle joints combined; mandibles (fig. 2, B and C) normal; wings uniformly ciliated, the speculum somewhat wider below and nearly connecting with the hairless streak on the posterior margin; ovipositor about one-third the length of abdomen, its sheaths pubescent. Length, 0.9 mm., exclusive of ovipositor.

Coloration almost uniformly pale yellow, about chrome lemon, the appendages concolorous, with apex of ovipositor black; wings hyaline, the veins pale yellowish; pubescence on head and body about as abundant as in the other species of the group, but not conspicuous except on face, where it is whitish or silvery.

MALE

Similar to the female, but the following differences may be noted: Frontovertex slightly wider or about one-half longer than wide, the ocelli in a slightly acute or almost equilateral triangle. Coloration the same, except that the dorsum of the abdomen at apex is orange yellow, separated from the paler base by a narrow, transversely arcuate dusky band between the vibrissae. Length, 0.7 mm.

Described from two females, two males (type, allotype and paratypes *a* and *b*) reared from *Pseudococcus yerbasantae* Essig, May 12, 1915, Sespe Cañon, California (C. P. Clausen), Clausen no. 67.

Table of Female Antennal Measurements (Length × Width) of Acerophagus in Microns

	Scape excluding radicle	Pedicel	Funicle 1	Funicle 2	Funicle 3	Funicle 4	Funicle 5	Club
A. fasciipennis	141×30	60×20	15×16	12×19	12×20	16×23	20×28	105×38
A. pallidus	180×36	82×25	18×18	18×20	18×20	18×25	24×30	129×54
A. gutierreziae	154×23	59×25	12×15	12×18	15×20	.....	.....	.....
A. notativentris	157×38	67×30	12×20	12×23	15×28	20×33	23×38	136×61
A. texanus	159×36	64×28	15×23	18×25	20×28	20×31	20×38	136×59

Stemmatosteres,[3] n. gen.

FEMALE

Head very thin anteroposteriorly, a little wider than thorax, the greater portion of frontovertex and face lying in one plane, which is very slightly convex; seen from in front, the outline is rounded, the occipital margin appearing truncate, the length and width about equal; in lateral view (fig. 3, B) the outline is narrowly and irregularly oval, the greatest thickness just below the eyes; in dorsal view (with head held vertically) only the vertex visible, sloping gently backward to the occipital margin, which is abruptly rounded, not sharp, its outline now appearing concave; occiput with a rather shallow, semicircular excavation on the dorsal half into which the prothorax fits, the neck being

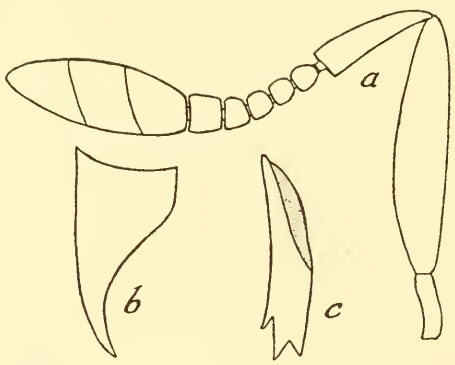

Fig. 2. *Acerophagus pallidus:* A, antenna of female; B, right mandible of male, exterio-dorsal view; C, same, anterior view.

inserted near the dorsal margin of the excavation, so that the head may be held either vertically or horizontally, the former position apparently being the normal or resting position in life; frontovertex considerably wider than long, the ocelli absent, the eyes small, oval, coarsely faceted; face abruptly rounded off to the oral margin from just above the antennal sockets, the scrobes entirely absent; cheeks a little longer than length of the eyes; antennae (fig. 3, C) inserted rather far apart and close to the

[3] From *στεμματοστερής*, deprived of stemmata, in reference to the lack of ocelli.

oral margin, a little less than half as long as body, distinctly clavate; the scape slender, compressed; pedicel as long as the first three funicle joints; the funicle five-jointed, all joints short, increasingly transverse, the fifth nearly twice as wide as long; club large, oval, not much wider than the last funicle joint and as long as funicle and pedicel combined, composed of two joints, the basal one being much shorter; mandibles (fig. 3, E) with three long, acute teeth, the ventral one far more basal, the upper two at the apex, with the middle one slightly longer. Thorax small, the visible portion of dorsum hardly more than one-half as long as abdomen; pronotum very large, fully as long as the mesoscutum and scutellum combined; mesoscutum very short and transverse, about four times wider than long; scutellum also short and transverse, a little longer than the scutum, the axillae coalesced with it, the sutures not at all visible unless insect is mounted in balsam; metathorax and propodeum concealed by the base of the abdomen, which overlaps the posterior part of the thorax so that the apex of the first abdominal segment and the posterior margin of the mesopleura lie in the same vertical plane; wings either absent or vestigial, the front pair visible in some specimens as minute, linear scales, no longer than the scutellum, bearing two bristles at apex and one on the side, hind pair of wings apparently entirely absent; legs short, normal, the middle tibial spur slender, tapering, a little shorter than the first tarsal joint, hind tibiae with two spurs, the smaller one half as long as the other. Abdomen large, oval, depressed, the first segment shortest, the second longest; ovipositor shortly protruded, otherwise enclosed by the fifth sternite, which reaches to the apex of the abdomen but does not become at all compressed; vibrissal plates situated at the apical fourth, the vibrissae reaching about to the apex. Surface of head and body nearly smooth, or very finely alutaceous, the frontovertex with extremely minute, shallow, scattered setiferous punctures; pubescence short, very delicate, pale colored, and hardly visible except under high magnification; coloration yellow, non-metallic, but with a pearly luster.

MALE

Much like the female, except that the abdomen is considerably shorter and wider, the antennal scape (fig. 3, D) a little wider and the club considerably longer and solid.

Type of Genus

Stemmatosteres apterus, n. sp.

This genus is anomalous in the absence of ocelli, in the structure of the antennal club, the reduction and peculiar configuration of the thoracic sclerites and the overlapping of the abdomen upon the posterior part of the thorax. The wings are probably never fully developed on account of the reduction of the mesonotum. The genus appears to be most closely allied to *Acerophagus* Smith.

Stemmatosteres apterus, n. sp.

Fig. 3

FEMALE

Head and body chrome lemon yellow, the dorsal surface of the head with a pearly luster (in life) which reappears to a less degree on other parts of the body; antennae dusky yellowish, purer yellow at the base of the scape; legs concolorous with body, dusky only at tip of the last joint of the tarsi; a linear mark on each side of pronotum at the neck, and the exserted portion of the ovipositor sheaths blackish; the vibrissal plates brown.

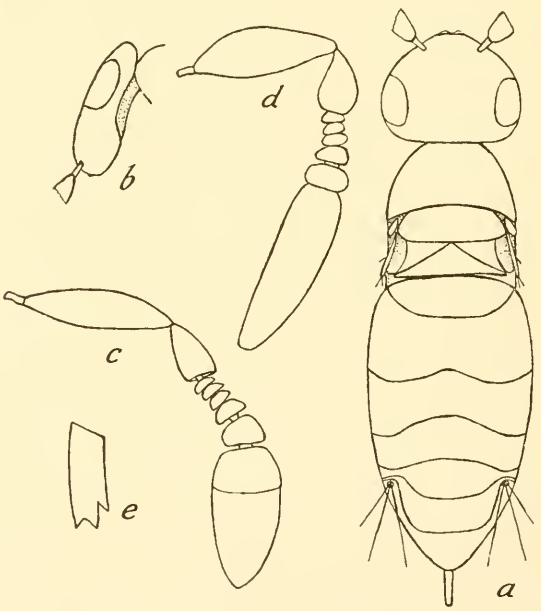

Fig. 3. *Stemmatosteres apterus:* A, female, dorsal view; B, lateral view of head, female; C, antenna of female; D, antenna of male; E, right mandible of female, ventral view.

Length, 0.5–0.6 mm. with head held vertically, 0.6–0.7 mm. with head extended horizontally, exclusive of ovipositor.

MALE

Colored like the female, except that the yellow is decidedly more of a chrome orange tint especially on the abdomen. Length, 0.4–0.46 mm. with the head vertical, 0.49–0.55 mm. with head horizontal.

Described from eight females, two males (type, allotype and paratypes *a* to *h*) reared from *Pseudococcus timberlakei* Cockerell, November 1–3, 1915, Millbrae (in salt marsh), California (P. H. Timberlake), Salt Lake Laboratory no. 1830 A.

Pseudococcobius Timberlake

This genus recently characterized (Proc. U. S. Nat. Mus., vol. 50, p. 563, May, 1916) appears on further study of the genotype and the additional species described below much more closely allied to *Aphycus* than was at first supposed, and the discovery of a few more species might well bridge the relatively slight gap between the two groups. The species belonging here are probably all parasitic in mealybugs, and the differences separating them from *Aphycus* appear to be an adaptation to their soft-bodied hosts. The abdominal character used in my recent paper on *Aphycus* to separate the two groups proves to be unreliable, as I have discovered since that the fifth sternite often reaches to the apex of the abdomen even in *Aphycus*, although there is no marked tendency towards compression of the abdomen as seen in *Pseudococcobius*. The mandibles, however, so far as they have been studied carefully, always have acute teeth in *Pseudococcobius* and blunt teeth in *Aphycus*, but otherwise do not differ much. The antennal club of *P. terryi* is not actually solid, as stated in my paper, but composed of three closely fused joints, as a study of fresh material proves, although it seems nearly if not quite impossible to distinguish them under ordinary circumstances.

Aphycus oaxacae Howard belongs in the *Pseudococcobius* group, as a reëxamination of the type discloses the fact that the mandibular teeth are acute. This species is similar to *P. fumipennis*, described below, in type of coloration but is quite distinct.

Pseudococcobius chrhorni is not congeneric with *terryi*, as the mandibles are distinctly bidentate and considerably more narrowed toward the apex. The antennae also are considerably

different. It is one of the apparently rather numerous forms that make a gradual transition between the more typical members of the Eetromatini and Mirini. The accession of fresh material of *chrhorni* permits a better understanding of its structural peculiarities, and it is consequently elevated to generic rank.

Pseudococcobius fumipennis, n. sp.

Fig. 4

FEMALE

Head as seen from in front hardly wider than long, not so thick anteroposteriorly as in *P. terryi;* frontovertex about one-half longer than wide; ocelli in an equilateral triangle, the posterior pair about one-fourth their own diameter from the eye-margin, the median one at the center of the frontovertex; eyes large, not pubescent, in outline nearly circular except for the dorsal orbits being parallel; cheeks moderately long, or about four-fifths as long as the diameter of the eyes; antennal scrobes moderately deep, meeting above in an acute angle; mandibles (fig. 4, B and C) with the teeth acute and nearly equal. An-

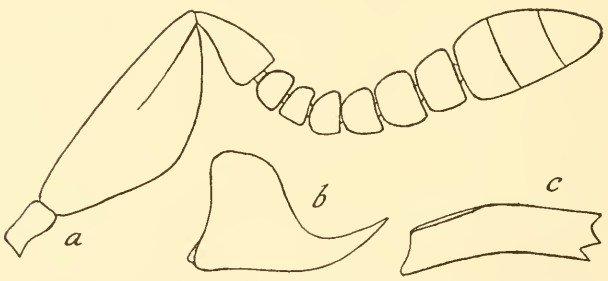

Fig. 4. *Pseudococcobius fumipennis:* A, antenna of female; B, right mandible of male, exterio-dorsal view; C, same, anterior view.

tennal scape (fig. 4, A) flattened and expanded below, nearly one-half as wide as long; pedicel about as long as the first three funicle joints combined; the funicle increasing gradually in width so that the sixth joint is a trifle more than one-half wider than the first, the first three, and especially the second, shorter than the last three joints, all increasingly wider than long; club large, oval, rounded at apex, a little longer than the last three funicle joints combined, and after collapsing one-third as wide again as the last funicle joint. Wings thickly ciliated, the cilia

a little weaker at apex; speculum narrow, reaching two-thirds of the distance to the posterior border of wings and well separated from a cut-off portion which is equally distant from the posterior wing-margin; bristles on the submarginal vein a little more developed than in *terryi,* but still weak. Length, 0.9-1.2 mm.

Lower part of face and cheeks, almost the entire upperparts of the body, and the venter of abdomen dull black, the latter with a small white spot on each side near margin at the base; frontovertex very pale ochraceous brown, narrowly margined on all four sides and narrowly striped down the middle or at least in the ocellar region with brownish black; upper portion of face and cheeks creamy white to flesh tinted, the pale area on face divided into two transverse bands by a blackish band of about the same width which stretches between the lower corners of the eyes; on the cheeks the pale area barely touches the lower corners of the eyes and is separated from the eye-margin posteriorly by a triangular blackish area continued forward as a narrow line and cutting across the lower corners of the eyes to unite with the black facial band; occiput pale ochraceous brown; collar of pronotum narrowly whitish with a blackish dot on each corner; tegulae pale brownish at the center and on the posterior margin, whitish on the anterior and lateral margins; underparts of thorax dull brownish black with the anterior corners of the mesopleura, and the prepectal plates whitish. Antennae brownish black, with an oval spot on dorsal, apical corner of scape, and the apical half of pedicel, with the last two funicle joints white, the club slightly paler at apex. Legs dull brownish black variegated with white as follows: apical portion of all coxae, the trochanters, the dorsal margin of front femora with apex and a small spot on ventral margin near apex; base and apex of middle and hind femora and a narrow band near apex of each, on the middle pair connecting on lower margin with the apical area; base of all tibiae and two narrow cross bands on each, less distinct on front pair; all the tarsi except last joint on front and middle pair and last two joints on hind pair, and the tibial spur white. Fore wings conspicuously smoky, due to integumentary pigmentation, gradually becoming clearer toward the apex and the base, with a small clear spot at the apex of the submarginal vein and a more deeply stained area at the juncture of the marginal and stigmal veins; hind wings hyaline.

MALE

Entirely similar to the female in structural and colorational characters, except that the last two funicle joints are brownish instead of white. Length, 1.2 mm.

Described from two females and two males (type, allotype, and paratypes *a* and *b*) reared from *Pseudococcus solani* (Cockerell), Uplands, California, June, 1914 (C. P. Clausen), Clausen no. 23.

Pseudococcobius clauseni, n. sp.

Fig. 5

MALE

Head rather thin anteroposteriorly, as seen from in front about one-fifth wider than long; frontovertex about twice as long as wide, the dorsal orbits of eyes parallel; ocelli in an acute-angled triangle, the posterior pair about one-half their own diameter from the eye-margin, and twice their own diameter from the occipital margin; eyes large, about one-fifth longer

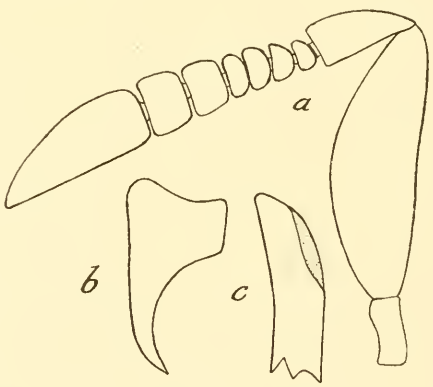

Fig. 5. *Pseudococcobius clauseni:* A, antenna of male; B, right mandible of male, exterio-dorsal view; C, same, anterior view.

than wide, thinly pubescent with short pile; cheeks as long as the width of the eyes; face with a moderately developed prominence between the antennae, the scrobes rather shallow, narrow and meeting above; mandibles (fig. 5, B and C) rather wide at apex with three sharp, nearly equal teeth, which are longer than in *P. fumipennis*. Antennal scape (fig. 5, A) flattened, moderately expanded below, about one-third as wide as

long; pedicel a little longer than the first four funicle joints combined; funicle increasing in width distad so that the sixth joint is over one-half wider than the first; the first four joints short, the first two a trifle longer than the third and fourth, each except the first about twice as wide as long, the last two joints nearly twice as long as the preceding, yet still wider than long; club solid, no wider than the funicle, a little longer than the preceding five joints combined, and obliquely rounded at the apex dorsoventrad; first five funicle joints with comparatively long and coarse pile, the sixth joint and club with a much thicker, finer and shorter pubescence. Wings with a narrow, curved cross band of weaker, paler cilia at the end of the stigmal vein; speculum very narrow but uniform, not quite reaching the stigmal vein nor more than two-thirds of the distance to the posterior margin; bristles on submarginal vein well developed. Abdomen about two-thirds as long as the thorax, triangular in outline, depressed, the base cordate. Length, 0.8 mm.

The frontovertex and upperpart of face to lower margin of eyes pale clay yellow, more cadmium yellow next to the orbits and dusky or brownish on vertex behind the ocelli; occiput, cheeks and lower part of face blackish brown, a paler brown, transverse spot above antenna; thorax and abdomen dull black with a slight brownish tint; the pleura more brownish, with most of the propleura, the prepectal plates and the anterior margin of the mesopleura dusky whitish; collar of pronotum whitish with a brown dot on each corner; tegulae blackish brown with anterior and exterior margin whitish. Antenna black, with the sixth funicle joint and the club white. Anterior legs pale brownish with most of the trochanter, the basal, inner, ventral margin and band close to the apex of the femora, the base and apex of tibiae and the tarsi yellowish white, the first and last two tarsal joints, however, dusky; middle trochanters and femora dusky white with a brownish streak on the under side of the latter, the tibiae whitish with base and apex narrowly blackish and with two brownish black annuli near their middle, the tarsi and tibial spur dusky yellowish, the last tarsal joint darker; hind legs similar to the front pair except that the tibiae have an additional, narrow white annulus at their middle, and the femora have their upper, inner margin whitish. Basal half of wings deeply smoky to the end of the stigmal view, with the apical margin of the area convex, and separated by a rather narrow, curved pale band from the slightly dusky apex of the

disk, the basal area being integumentarily stained although strengthened by the dense, dark colored ciliation, the apical dusky area, however, entirely ciliary in origin. Pubescence of head and body whitish and conspicuous on the dark parts.

Described from one male reared from an *Erium* species on cactus, Riverside, California, October, 1914 (C. P. Clausen), Clausen no. 10.

Cirrhencyrtus,[4] n. gen.

FEMALE

Head moderately thick anteroposteriorly, the dorsal surface convex, passing over into face by a rather abrupt curve, the frontovertex moderately wide, the ocelli in a right-angled triangle, the posterior pair close to the eye-margin and much farther removed from the occipital border; seen from in front, the head is about as wide as long, the cheeks a little longer than width of eyes and converging toward the broadly truncated oral margin; seen from the side, the head is subtriangular in outline; occiput uniformly but not deeply concave, the neck inserted at the center;

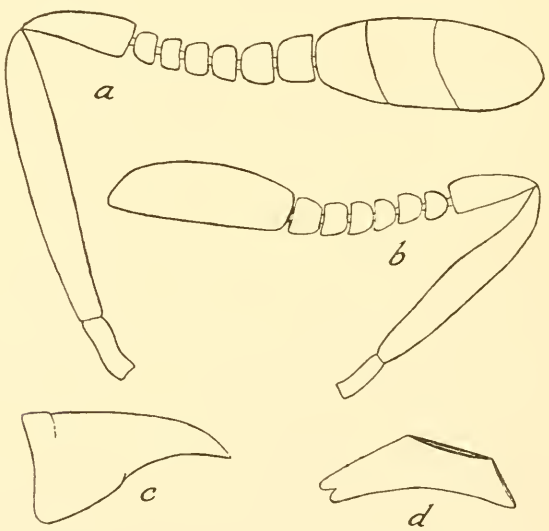

Fig. 6. *Cirrhencyrtus chrhorni:* A, antenna of female; B, antenna of male; C, left mandible of female, exterio-dorsal view; D, same, anterior view.

[4] From Κιρ'ρός, tawny yellow, and *Encyrtus.*

eyes moderate in size, oval, one-third longer than wide, slightly pubescent; mandibles (fig. 6, C and D) narrowed toward apex with two nearly equal, blunt or rounded teeth, of which the dorsal is more apical; antennal scape (fig. 6, A) cylindrical, moderately long, reaching considerably beyond plane of front, pedicel as long as the first four funicle joints; funicle six-jointed, increasing slightly in width distad, all joints short, transverse; club large, oval, somewhat longer than the funicle, in life hardly wider than funicle, but after death collapsing so that it is much wider, its sutures plainly visible, the last joint longest with a rounded area of softer tissue at its apex. Thorax of normal structure, the pronotum arched, the mesoscutum transverse, the axillae meeting medially, the scutellum flat, triangular with apex slightly rounded, its sides abruptly declivous; wings large, uniformly ciliated, with oblique hairless streak or speculum; marginal vein punctiform, stigmal moderately long, its apex triangularly enlarged, postmarginal nearly as long as the stigmal, but rapidly tapering and becoming transparent, bristles on submarginal vein reduced; costal cell of hind wing narrowed distad but extending to the hooklets; legs longer and slenderer than normally, especially the middle pair, the middle tibial spur moderately long and slender, shorter than the first tarsal joint. Abdomen rather subquadrate in shape, its sides nearly parallel, the apex subtruncate; excluding the ovipositor, which is slender and prominently protruded, its length is about equal to two-thirds of the thorax; the venter not at all compressed, the fifth sternite reaching to the apex. Sculpture alutaceous, the frontovertex more coarsely so; vestiture moderately abundant, dark colored on the thorax; coloration flavous, the collar of pronotum, tegulae and appendages concolorous.

MALE

Very similar to the female, but the frontovertex is wider, the ocelli larger, the antennae (fig. 6, B) a little shorter with slightly longer, thicker pubescence, the club solid and slenderer, the postmarginal vein considerably shorter, and the abdomen more ovate.

Type of Genus

Pseudococcobius ehrhorni Timberlake

Cirrhencyrtus ehrhorni (Timberlake)

Pseudococcobius ehrhorni Timberlake, Proc. U. S. Nat. Mus., vol. 50, p. 564, 1916.

Fig. 6

The male hitherto unknown differs from the female as follows: Frontovertex about one-fourth longer than wide; antennae a little smaller, more pubescent, the club obliquely acuminate on the upper side. Coloration the same, except that the black dots on venter at apex are absent, the metapostnotum and the abdomen above at center blackish brown, and the antennae pale brownish with base of scape alone yellowish. Length, 1.1 mm.

One male and female reared from *Pseudococcus ryani* (Coquillett) Berkeley, California, August 20, 1914 (C. P. Clausen), Clausen no. 21.

Tribe ECTROMATINI

Tanaomastix,[5] n. gen.

FEMALE

Head as wide as thorax, submenisciform, thin anteroposteriorly, the face to a slight degree inflexed; seen from in front, subcircular in outline with cheeks converging toward mouth at nearly a right angle, about as wide as long; seen from the side, in outline subtriangular, the facial side longer than the dorsal side, the latter being convexly rounded; occiput concave, the neck inserted near the center, the occipito-vertical margin acute; frontovertex rather broad, as wide as long, the ocelli in a right angle, the posterior pair farther removed from eye-margin than from the occipital margin; eyes large, broadly oval, a little wider on lower half, the dorsal orbits nearly parallel, posteriorly reaching to the occipital border; face reaching considerably upward between the eyes, a little longer than wide, the scrobes distinct but not deep, converging above but not meeting, separated by a very slightly arched ridge, which is hardly visible in side view of head; cheeks short and narrow, hardly longer than one-half the width of the eyes; mandibles normal for tribe, long and narrow with two acute teeth; antennae (fig. 7, B) inserted close

[5] From *ταναός*, tapering, long, and *ἡ μάστιξ*, whip, in reference to the antennae.

to a line drawn between the lower corners of the eyes, about equidistantly from each other as from eyes and clypeal margin, in form long and slender as in *Leptomastix* (Förster) Mayr, the scape flattened but hardly expanded, the pedicel about equal to the first funicle joint, the funicle filiform; all the joints much longer than thick, not increasing in width distad, the club after collapsing a little thicker than the funicle and a little longer than the last two joints combined. Thorax short and thick, the dorsum but slightly convex; pronotum short, arcuate; mesoscutum about twice as wide as the median length; axillae lying in same plane with scutellum, meeting or nearly meeting medially; scutellum flat, abruptly declivous at the sides, the apex rounded; metanotum and propodeum both short, almost divided medially, the side pieces triangular, the propodeum also very abruptly

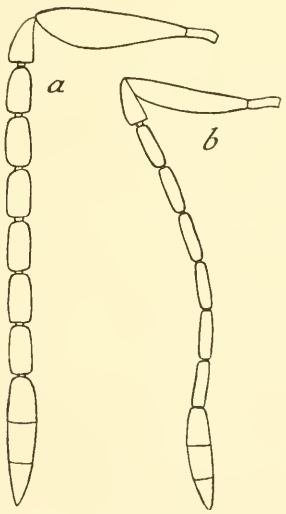

Fig. 7. *Tanaomastix:* A, female antenna of *T. claripennis;* B, same of *T. abnormis.*

deflexed and overlapped by the abdomen; legs long and slender, the middle tibiae noticeably longer than their femora, the spur a little shorter than the first tarsal joint, which is almost as long as the following four combined, hind tibia with one small apical spur; wings narrow, elongate, the costal cell very narrow, marginal cilia short, marginal vein about three times as long as thick, the stigmal slightly longer, straight and enlarged at apex, the post-marginal considerably longer than the stigmal; hind wings

linear, the costal cell extremely narrow or evanescent, the vein but slightly bent. Abdomen as seen from above acutely triangular in outline; the dorsum deeply concave, the venter strongly compressed; the ovipositor entirely enclosed within the fifth sternite which reaches to the apex; the vibrissal plates situated at the base and withdrawn within the dorsal concavity.

Sculpture entirely alutaceous, the frontovertex much more coarsely so or closely granulose, pubescence on head scanty and very fine, on mesonotum more evident and arising from microscopic punctures. Coloration non-metallic.

MALE

Not differing noticeably from the female except in the structure of the antennae, which are somewhat longer, the scape about the same, the pedicel much shorter than the first funicle joint or hardly longer than thick, the funicle joints all elongate, slender, incised at each end above except at base of first joint, each clothed with rather long erect hairs arranged in three whorls, the apical whorl somewhat incomplete on lower side, club solid, no thicker than the funicle, and about one-half longer than the preceding joint; the abdomen also does not become sunken in, and the dorsum is more coarsely sculptured than in the female.

Type of Genus

Paraleptomastix abnormis Girault

The two other species so far known show but little deviation from the above description based entirely on *P. abnormis,* the chief differences residing in the shape of the head, and the length of the middle tibial spur in comparison with the first tarsal joint as brought out in the following descriptions and notes.

The genus is most closely related to *Leptomastix* (Förster) Mayr, which differs in having the head menisciform, the face not at all inflexed, the scrobes meeting above and separated by a strongly arched ridge prominently visible in side view of head; the antennae inserted higher up or between lower corners of eyes; the pedicel not over one-half as long as the first funicle joint; the funicle clothed with stiff bristle-like hairs in the female, and with longer hair in the male arranged in three whorls on basal three joints and in two whorls on apical three; the club in male with a fringe of short bristles on lower margin of basal half; thorax more convex; wings wider and the postmarginal

variable, in *P. histrio* and *P. dactylopii* not longer than stigmal, but in an undescribed species considerably longer. (The above characters based mainly on *L. dactylopii* Howard.)

Paraleptomastix Girault does not seem to be so closely related, as it is a large, robust form of different sculpture and metallic coloration; the head menisciform, the scrobes very short (no facial ridge mentioned by Girault), the antennae slenderly clavate, the funicle joints becoming shorter and thicker distad, the sixth being a little wider than long, the pedicel less than half as long as the first funicle joint; wings probably much wider than in *Tanaomastix*, as the costal cell is wide; stigmal vein curved, longer than the marginal; the hind legs compressed, the femora narrowly exfoliate.

The species of *Tanaomastix* are parasitic in mealybugs of the genus *Pseudococcus* so far as known. In life the wings are held semivertically erect over the back, at least in *abnormis*, a habit quite unique among the Encyrtinae.

Tanaomastix claripennis, n. sp.

Fig. 7, A

FEMALE

Head wider than in *T. abnormis*, the frontovertex about one-fourth wider than long and coarsely alutaceous or granulose; ocelli large, in an obtuse-angled triangle, the posterior pair about their own diameter from the occipital margin and fully twice as far from the eye-margin; eyes about one-fifth longer than wide, with a fine, sparse pubescence; cheeks about as long as the width of eyes; face as wide as long, the antennal scrobes narrow, rather deep and not uniting above, the facial ridge hardly elevated. Antennae (fig. 7, A) noticeably less slender than in *abnormis;* the scape somewhat expanded below, its greatest width just distad of the middle a little more than one-fourth the length exclusive of the radicle; pedicel as long as the first funicle joint; funicle joints about equal, all about twice as long as wide; club hardly wider than funicle, as long as the two preceding joints and one-half of the next combined, its three joints subequal, the apex pointed. Wings considerably wider than in *abnormis*, uniformly ciliated; the speculum wide, not quite reaching stigmal vein nor more than three-fifths of the distance to the posterior margin. Legs as in *abnormis*, except that the middle tibial spur and the first tarsal joint are each considerably shorter than the last four tarsal joints combined. Length, 1.0 mm.

Frontovertex orange yellow, with the occipital margin dusky; face, cheeks and sides of head yellowish white, the cheeks slightly dusky on the sides; the face with a narrow, dark brown band on each side connecting the lower corner of the eye with the base of the antenna; occiput dilute blackish brown; the notum of thorax and apical half of abdomen above and below brownish black, the lateral margin of mesoscutum and the axillae pale orange yellow, the metanotum, propodeum, metapleura and basal half of the dorsum of abdomen pale brown; underparts of thorax otherwise yellowish white, and most of the basal half of the venter dusky white. Antennae dark brown, the scape with a white triangular spot on the outer and inner surface beginning almost at the base, not quite reaching the dorsal margin but reaching to the middle on the ventral margin, with a narrow, oblique, curved band running from the dorsal margin a trifle beyond the middle to the ventral margin just before the apex. Legs yellowish white, the middle coxae dark brown, the fore and hind tibiae on dorsal margin, all femora on dorsal margin at apex, and the fore and hind tarsi, pale brownish or dusky, the middle tibiae and tarsi very dilute brownish yellow with the first tarsal joint and the spur whitish. Wings hyaline, the veins brown. Pubescence of thorax pale brown and inconspicuous.

Described from two females (type and paratype) reared from *Pseudococcus ryani* (Coquillett), Pasadena, California (C. P. Clausen), Clausen no. 56.

Tanaomastix abnormis (Girault)

Fig. 7, B

Leptomastix sp. Viereck, Monthly Bulletin, Cal. State Comm. Hort., vol. 4, p. 208, fig. 36–38, April, 1915.

Paraleptomastix abnormis Girault, Entomologist, vol. 48, p. 184, August, 1915.

Paraleptomastix abnormis H. S. Smith, Jour. Econ. Ent., vol. 10, p. 262–68, figs. 9–13, pls. 13–14, April 21, 1917.

As compared with *T. claripennis* this species has the frontovertex no wider than long, the face longer than wide, with the facial ridge more elevated, the antennae (fig. 7, B) much slenderer, each funicle joint being about three times longer than thick, and the middle tibial spur considerably longer. It has about the same coloration, excepting the following points: the frontovertex paler orange yellow, the face without dark marks, the notum of thorax varying from dark to pale brown, the base

of the abdomen more whitish, the legs paler, the scape of the antenna except the dorsal margin and the apex of the pedicel white, and the wings conspicuously trifasciate, the bands due both to integumentary pigment and to the ciliation.

A female reared from a *Pseudococcus* on *Citrus* (not *Pseudococcus citri* Risso), Okitsu, Japan, July, 1914 (Kuwana), California State Insectary no. 783, is entirely similar to specimens from Sicily, except that the blackish streak on the dorsal margin of the scape does not quite reach the apex. This species has been introduced into southern California from Sicily to help reduce the citrus mealybug (*Pseudococcus citri* Risso), and, according to the latest reports, has become established.

Tanaomastix albiclavata (Ashmead)

Aphycus albiclavatus Ashmead, Proc. U. S. Nat. Mus., vol. 29, p. 404, 1905.

This species as compared with *T. abnormis* has a thicker, narrower head, with the frontovertex nearly twice longer than the posterior width, the dorsal orbits of eyes slightly converging behind, the ocelli in an acute angle, the posterior pair close to the eye-margin, the scape subexpanded below, the scutellum more acute at apex, and the spur of the middle tibiae fully one-half as long as the tarsi.

The above notes are based on one female from the Philippine Islands (undoubtedly from the vicinity of Manila), reared from a *Pseudococcus* species, and received from the California State Insectary. It agrees with Ashmead's type specimen, which is a female, and not a male, as stated in the original description.

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Vol. 1, No. 9, pp. 369-464, plates 2-16 November 21, 1922

THE TAXONOMY OF THE MASARID WASPS, INCLUDING A MONOGRAPH ON THE NORTH AMERICAN SPECIES

BY
JAMES CHESTER BRADLEY

Smithsonian Institution
DEC - 7 1922
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UNIVERSITY OF CALIFORNIA PRESS
BERKELEY, CALIFORNIA
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THE TAXONOMY OF THE MASARID WASPS, INCLUDING A MONOGRAPH ON THE NORTH AMERICAN SPECIES

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JAMES CHESTER BRADLEY

INTRODUCTION

Fifteen years ago, having before me all the described North American masarid wasps, I prepared tables for their identification. This was an interesting and easy task, as their characters are distinct and easily described. The manuscript remained unpublished while I awaited opportunity to determine the relations of American species of *Masaris* with the North African *vespiformis,* the type species of the genus. Later, at the suggestion of Dr. Joseph Bequaert, I renewed the study of this group, rewrote the tables, and added descriptions of all the North American species.

I have studied the wings, mouth parts, and male genitalia of all the North American species, and of species of several exotic genera. The results are of interest particularly in establishing clearly the relations of American species with *Masaris* of North Africa and with *Trimeria.* In addition, sufficient facts have been disclosed to make advisable a tentative revision of the classification of the family, which I present in the form of the subjoined tables. In view of the scantiness of my material, I do not presume to think that this classification will have more than a temporary value, but I do believe that it is an improvement, taxonomically speaking, over what has preceded, and it will at least correct certain errors in the existing keys.

Since the days of de Saussure two keys to the genera of Masaridae have been published. The one by Ashmead in the *Canadian Entomologist,* volume 34 (1902), page 219, will lead the unwary user astray for the following reasons: (1) a primary division (category 3) reads "labrum extensible" where "ligula" is meant, and if not corrected is unintelligible; (2) *Paraceramius, Ceramius, Ceramioides, Trimeria,* and *Jujurhta* [sic] are described as having the "labrum [i.e., ligula] not extensible," which is incorrect for these genera; (3) the character used in category 8 (marginal cell with or without an appendage) will not serve to distinguish between the groups for which it is intended; (4) the claws of *Masaris* are incorrectly described as being simple, and several other characters are thus incorrectly described and wrongly applied. The second key is a compilation by Dalla Torre published in the *Genera Insectorum,* 1904, fasc. 19, and contains most of Ashmead's errors and some additional ones.

I wish to express my acknowledgments and gratitude to Dr. Joseph Bequaert, who has contributed fertile suggestions and has taken much interest in the prosecution of this work, and has loaned me, with permission to dissect it, a female of *Celonites,* as well as specimens of *Gayella* and *Trimeria.* Acknowledgments are further extended to Dr. F. E. Lutz, for the loan of specimens of *Paragia* from the American Museum of Natural History, with permission to dissect them; to Dr. Henry Skinner, for the loan of several species of *Pseudomasaris* from the collection of the American Entomological Society, and to the authorities of the United States National Museum for courtesies extended to me while visiting that institution.

TAXONOMY OF THE MASARID WASPS[1]

The Mouth Parts and Their Value in Classification

The remarkable retractile ligula of most of the genera of Masaridae has been both figured and described by de Saussure, and I do not need to dwell upon it here. When withdrawn, which is accomplished by a process of introsusception, only the tip of the ligula is exposed, the

[1] *Explanation of the text.*—Under each genus is listed all of the species known to belong to it, but references to literature are given only since the time of Dalla Torre's *Catalogus Hymenopterorum.*

The color nomenclature is chiefly that of Ridgway's *Color Standards and Color Nomenclature.*

median parts being coiled in a great loop which may at times enormously distend the membrane of the neck. The character is a very positive one, involving the entire shape and structure of the ligula, and certain chitinized basal plates. These plates seem to be developed for the purpose of assisting in effecting the invaginating process, and there can hardly be any transition between the two conditions. This ligula is the character to which Ashmead has reference in his key to genera, writing, however, by a slip of some sort, "labrum extensile" or "labrum not extensile." The character may be usually made out under a binocular microscope without dissection, and very readily and positively by dissecting out the mouth parts; but it is a curious fact that de Saussure, owing to the poorer optical instruments available in his day, has described the condition wrongly in several genera. These errors have stood in literature until the present time.

Dr. Bequaert suggested to me that the number of palpal segments is of very doubtful generic value in the diplopterous wasps. The last joints, he says, are very apt to drop off on the emerging of the adult, or later, and furthermore there are all sorts of variations within the limits of a single genus, such as *Odynerus*. Granting that, I can not believe that the case is entirely similar in the Masaridae. My dissections agree perfectly for the most part with the figures and descriptions of de Saussure except in the case of *Celonites*. I can not believe that apical segments could be lost without leaving indications of the fact. The shape of an ultimate segment is different from that of a penultimate. I have examined all the North American species, and find within the genus *Pseudomasaris* no variation in the maxillary palpi (which are always rudimentary), and no variation in the labial palpi of the females, which are of a peculiar type, 3-segmented, but very different from the palpi of the males, even when the latter are 3-segmented. The latter vary from 1- to 3-segmented, showing progressive reduction by coalescence of the segments, as is perfectly apparent from an examination of the series. In this case it would be futile to use the number of segments of this sex as a generic or even subgeneric character. Still more surprising is the similar sexual difference in both the pairs of palpi in *Celonites*, and especially that it should have apparently escaped detection. Analogous sexual differences may, of course, exist in other genera, and within some genera there may be variation in the number of segments, as, for example, in the labial

palpi of males of *Pseudomasaris;* but I think that the variation is not likely to be such as to affect the validity of the general arrangement here laid down, although it may of course affect the details. Such variations as occur are most probably to be found within the middle groups, not at either end of the series, and especially not within the final group of three genera in which the maxillary palpi are reduced to tubercles.

The Wings and Their Taxonomic Significance

The wings display taxonomic characters of considerable importance which have been largely overlooked by previous authors. The characters that have been used are three: (1) the number of submarginal cells, (2) whether the first receives both recurrent veins, or the second and third each receive one, and (3) the presence or absence of an anal lobe in the hind wings. These characters are all of value, but the story told by the wings is still far from being finished.

THE POSTERIOR LOBE

In a forthcoming paper on the wings of Hymenoptera I shall discuss the nature of the posterior (i.e., anal) lobe of the hind wings throughout that order. In the more primitive Hymenoptera it is a large area separated from the rest of the wing membrane by a marginal notch, the axillary excision. This lobe and the excision are not confined to the wings of Hymenoptera, but have their homologues in other orders. The position of this notch is always at the apex of the second anal furrow, which lies between the second and the third anal veins. The notch may be retained long after both fold and veins disappear.

Anterior to the axillary excision is another notch, the preaxillary excision. It is always situated at the apex of the first anal fold, which lies invariably just cephalad of and close to the first anal vein (anal vein), crossing M_3 (the submedian vein) shortly before its union with 1st A. Between the preaxillary and the axillary excisions is an area which I shall call the preanal lobe. Very often the preaxillary excision is reduced to a mere undulation of the wing membrane, but its position and that of the anal furrow are the most characteristic features of the topography of the hind wings.

In the more primitive members of each of the major groups of aculeate Hymenoptera (i.e., Formicoidea, Vespoidea, Scolioidea, Sphecoidea, and Apoidea) both axillary and preaxillary excisions are present, and accordingly both posterior and preanal lobes are well developed. Each have been lost in some or most of the specialized members of each superfamily. The tendency of specialization throughout the aculeates has been toward a reduction of the anal area of the hind wing, and especially of the posterior lobe.

With this tendency to reduction in mind, let us turn to *Euparagia*, representing the Euparagiinae, and consider the wing (fig. 100). The posterior lobe is large, two-thirds the length of the cell $M_3 + Cu + Cu_1$. In all other subfamilies except the Vespinae the posterior lobe is reduced to a small round or oval flap at the extreme base of the wing, from one-fifth to one-third the length of the cell $M_3 + Cu + Cu_1$. In the Vespinae the posterior lobe has been so completely reduced that it is altogether wanting. In this respect, as in others, *Euparagia* stands out alone as ancestral, while the Vespinae take their place as most specialized.

In all cases except the Vespinae the preaxillary excision is an insignificant notch, a mere undulation, or is altogether lacking. In the Vespinae it is deeper. Taking the order as a whole, it would seem that the primitive condition of the preaxillary excision is a distinct notch, but not a deep incision. The precise condition seems subject to variation within narrower limits than in the case of the axillary.

In the Vespinae the anal area of the hind wing is greatly reduced, so that the wing is subpetiolate.

THE CENTRAL AREA OF THE HIND WINGS

The venation of the central area of the hind wings is of considerable taxonomic importance. By referring to figures 97–101 and 104, plates 13, 14, 15, the modification it has undergone will be seen. Figure 98 represents a primitive condition (for aculeates) in which M_3 is transverse, m and M_2 are inserted below its middle, and the caudal part of M_3 is interrupted just before its union with $M_4 + Cu_{1+2}$ + 1st + 2d A by a bulla. The bulla is formed by the crossing of the 1st anal furrow, which is present, and which is lying immediately cephalad of 1st A and its amalgamates. The furrow ends in a preaxillary excision.

In Euparagiinae (fig. 100) this primitive condition is maintained except that m has migrated cephalad along M_3 to the point of separation of the latter from M_4. The crossing of M_3 by the first anal furrow is represented by a bulla, and the very faintest trace of the apical section of 1st A and its amalgamates is to be seen.

The subfamilies, which have ordinarily been classed as Eumenidae and Vespidae proper, are represented by figure 99. The vein M_3 is strongly angled, receiving m and M_2 at the angle. Both the latter vein and the apical section of 1st A and its amalgamates are ordinarily retained as fully formed veins, in some cases only as traces, but they are never wholly lost. First A ends, as always, in the preaxillary excision.

The Masaridinae have been derived from the type of figure 99 by the complete dropping out of the apical section of 1st A and its amalgamates. The wings of this subfamily are represented by figure 101, and what has happened to them is diagrammatically shown in figure 104. In the latter case the lost apical section of 1st A and its amalgamates and the anal furrow are represented respectively by a dotted and a dashed line.

In all of the Masaridinae the bulla indicating the crossing of M_3 by the first anal furrow has been lost, and as the vein formed by the union of M_3 with $M_4 + Cu_{1+2} + 1st + 2d$ A has straightened out it is impossible to point out the exact spot where it occurs.

The evidence for this interpretation of the hind wing of the Masaridinae lies in the position of the preaxillary excision. It is not the obvious interpretation from a casual examination of the wing, and in the keys I have referred to the condition as "M_3 apparently straight and m lacking."

In the Gayellinae (fig. 97) both the apical section of 1st A with its amalgamates and m and M_2 are fully preserved, but the vein m and M_2 has migrated apicad along m-cu to a point remote from M_3, a condition not infrequent in other aculeate Hymenoptera, but not occurring elsewhere in the Vespidae. M_3 is transverse and straight, therefore primitive, as in *Euparagia,* while the sidewise migration of m and M_2 must be considered a specialization.

THE MEDIAL AND CUBITAL REGIONS OF THE FOREWING

Coincident with the longitudinal plaiting of the wings of many Vespidae there has been a shifting and realignment of the veins in the central part of the wing, through which 1st A and Cu_2 + 1st A, M_4, M_{3+4}, M_{1+2}, $R_5 + M_{1+2}$, and $R_5 + M_1$ together form a more or less unbroken straight bar obliquely across the wing. The plaiting occurs just caudad of this bar. At the same time $M_4 + Cu_1$ is greatly shortened, and is situated much farther basad than usual; m-cu is inserted basad of $M_4 + Cu_1$ and the intervening section of Cu_1 is deflexed toward 1st A and Cu_2. The cell M_3 is triangular, elongated basally, and pointed, the apex truncate. The condition just described is exemplified by the wing of *Mischocyttarus*. While varying in detail it is the general condition throughout the subfamilies having longitudinally plaited wings.

In the Masaridinae it is evident that the same tendencies of specialization have been operative, but they have not proceeded in any case to so high a degree of perfection. Of the genera figured, *Paragia, Celonites, Ceramioides, Ceramius,* and *Trimeria* approach the condition most nearly. In each $M_4 + Cu_1$ is situated apicad of m-cu, the intervening sector of Cu_1 being deflexed. In these genera the cell M_3 is narrowed or pointed at base (*Paragia*), and triangular (*Paragia, Celonites, Trimeria*), or somewhat triangular (*Ceramius* and *Paraceramius*) in form. In *Masariella, Masaris,* and *Pseudomasaris* $M_4 + Cu_1$ is longer than in the other genera, and is opposite m-cu (*Masariella*), somewhat basad of it (*Masaris*), or its own length basad of m-cu (*Pseudomasaris*). Consequently, in these genera, the cell M_3 is less narrowed (though still unusually narrow) at base, and less triangular in form; and the veins Cu and Cu_1 instead of 1st A and Cu_2 + 1st A form a straight bar with M_4. In other words, these genera are in this respect more primitive than others, and show different stages in the type of specialization that goes hand in hand with longitudinal plaiting of the wings, and culminates in the venation exemplified by *Mischocyttarus*.

The apex of the cell M_3 is closed by the vein M_3, which may be straight, or slightly curved, as in all wasps with longitudinally plaited wings (see fig. 98, of *Mischocyttarus*), as well as in some Masaridinae (*Paragia, Celonites, Trimeria, Masaris, Pseudomasaris*); or it may be angled at the point of receiving m and M_2, the angle being (on the

side of the cell M_3) always less than 180°. This is the case in other Masaridinae (*Ceramioides*, *Ceramius*), and in Gayellinae. In Euparagiinae the angle is about 125°, the upper part of the cell M_3 being produced apicad to a point closer to the cell R_5 (measured along M_{3+4}) than the length of the cephalic section of M_3, a condition not obtaining elsewhere in the Vespidae, and giving to the wing of *Euparagia* a peculiar facies. In the Gayellinae the condition in this region of the wing is almost identical with that found in *Ceramoides*—$M_4 + Cu_1$ being a little longer than in that genus.

In Euparagiinae, apart from the prolongation of the upper apical angle of the cell M_3, the condition of this region of the wing is more primitive than obtains elsewhere. $M_4 + Cu_1$ is not abnormally far basad in the wing, is opposite m-cu and two-thirds as long as that vein, so that the cell $Cu + Cu_1$ is wide at apex. By reason of the fact that the veins $M_4 + Cu_1$ and M_3 approach each other, the caudal margin of the cell M_3 is scarcely longer than the basal width of the cell, a condition very far from being the case in any other Vespidae.

THE RADIAL REGION OF THE FOREWING

The most primitive condition of the radial region of the forewing occurs in Euparagiinae, Gayellinae, and Raphiglossinae, in which cells R_4 and R_5 are distinct, receiving, respectively, veins M_2 and M_{3+4}.

In Zethinae, Eumeninae, Stenogastrinae, Epiponinae, Rhopalidiinae, Polistinae, and Vespinae the base of the free part of the vein M_2 has migrated basad toward M_{3+4} until they both are opposite the cell R_5.

In Masaridinae these two veins are in the position just indicated, or in an intermediate position, but an additional step is found in the loss of the vein R_5, throwing the cells R_4 and R_5 together.

In the Euparagiinae, Masaridinae, and Gayellinae an appendiculate cell is always present, and in the first two of these subfamilies the cell 2d $R_1 + R_2$ does not extend farther toward the wing apex than does the cell R_4. In the few genera in which this is not the case both cells, and, in Gayellinae and in most of the genera of Vespidae with plaited wings, the cell 2d $R_1 + R_4$ extend closer to the wing apex than they do in Masaridinae. In Stenogastrinae this condition is carried to an extreme.

In the Vespidae with folded wings an appendiculate cell is rather exceptional.

THE PREANAL EXCISION OF THE FOREWINGS

Most Hymenoptera have a notch (the preanal excision) in the margin of the forewing opposite the tip of $M_{3+4} + Cu_{1+2} + 1st + 2d + 3d$ A. In most Vespidae this is present except in Euparagiinae, where it is lacking.

THE RANK OF THE "MASARIDAE"

Not accepting the eumenid wasps as a family distinct from the Vespidae, I can still less consider the masarid wasps as a separate family. Certain tendencies develop within the masarid line which are sufficiently distinct from what we find in the other solitary Diploptera and social wasps, but in every instance such characters are developed within the group, and we can always find genera displaying conditions of the same organs which do not differ from those of other Diploptera. It is worth while to briefly review the organs that have been relied upon for distinguishing between the three so-called families.

The *mouth parts* of the more highly specialized Masaridinae, by reason of the retractile ligula, differ completely from those of other Diploptera. The tendency to great or total reduction of the number of palpal segments and of the size of the palpi is also an important group characteristic. But in *Euparagia* and *Paragia* the ligula is not retractile, and neither it not the other mouth parts differ otherwise from the simple conditions found in the Eumeninae.

The *antennae* in the more highly specialized Masarinae have segments 8 to 13 of the male fused into a club, the divisions between them discernible except that between segments 12 and 13, which is not to be discovered unless the specimen be boiled in caustic potash, in which case the minute segment 13 may sometimes be observed. The antennae of the females have a similar club, but usually differing in shape. In *Euparagia*, however, the male has 13 distinct and entirely separated segments without a club, the apical part of the flagellum being merely slightly thickened. In *Paracerамius lusitanicus* the antennae of the male have the apical segments hooked, as in many male Eumeninae, not clavate, and consisting (as in a few Eumeninae) of 12 segments.

The *wings* of Masaridinae are ordinarily not longitudinally plaited, and this is used by some authors as the one character for separating the "family" from other Diploptera. In *Celonites,* however, the wings are as completely plaited as in any other Diploptera.

The majority of Masaridinae have cells R_4 and R_5 of the forewing united (two closed submarginal cells), whereas in most other Diploptera these cells are separate (three closed submarginal cells). In *Euparagia,* however, cells R_4 and R_5 are separate, and also in one or two of Cameron's genera (if they be really Masaridinae). While most other Diploptera have both the veins M_{3+4} and M_2 arising from the cell R_5, a few genera (*Raphiglossinae*) agree with *Euparagia* in having M_2 arise from the cell R_4.

While most Masaridinae have toothed claws, like many eumenid Diploptera and unlike most vespid Diploptera, certain genera, as *Pseudomasaris,* etc., have simple claws, as has also *Euparagia.*

The vespid Diploptera usually have two spurs on the middle tibia; the Eumeninae proper have only one, but several species usually classed as Eumenidae have two. Many genera of the Masaridinae have two spurs, several genera have one, and sometimes the number varies within the genus.

I am familiar with the male *genitalia* of only a few genera of Vespid and of Eumenid Diploptera. In these the squama is acute at apex and separate from the ramus. In Masaridinae it is more often blunt and almost always fused to the ramus. But in *Euparagia* it is separate as in other Diploptera. The genitalia of some genera of Masaridinae differ more radically from the more primitive condition found in other Masaridinae than do the latter from those of *Vespa* or *Odynerus.*

In many of these characters *Euparagia* is the connecting link that breaks down the distinctions between other "Masaridae" and "Eumenidae." As a result, the only tenable rank for the masarine wasps, it seems to me, is as one or two subfamilies, along with the several subfamilies into which the old families Vespidae and Eumenidae may best be divided, of the single comprehensive family, Vespidae.

Key to the Subfamilies of VESPIDAE[2]

A. Transverse median vein (M_3) of the hind wings straight or curved, not angled; the discoidal vein (m) usually wanting, or vague, in which latter case[3] the median vein, the submedian and the cubitus and the discoidal veins (m, M_4, M_5, and m-cu) meet at a common point (*Euparagia*), or the discoidal vein is completely formed, arising from the cubitus far apicad of the transverse median vein (*Gayella*); only in *Gayella* are the discoidal vein and the apical sections of radius, cubitus and the anal vein (R_5, $R_{4+5} + M_1$, m and M_2, and 1st A) all distinctly formed veins. In all other cases one of these is entirely wanting and the rest are usually only indicated as traces. Forewings with two or three submarginal cells, in the latter case the second and third each receiving a recurrent vein (veins M_2 and M_{3+4} arising opposite cells R_4 and R_5, respectively). Anal lobe of the hind wing always present, but the preanal excision absent or indistinct.

B. Anal lobe of the hind wing elongate, more than one-half the length of the submedian cell ($M_3 + Cu + Cu_1$). Second discoidal cell of the forewing (cell M_3) of irregular shape, not pointed at base, its apex greatly produced above toward the apex of the wing; the section of the discoidal vein between the 1st recurrent and the subdiscoidal veins (M_3 cephalad of m) almost longitudinal in position, longer than the first recurrent vein (M_{3+4}) and forming an angle of more than 180° with its section caudad of the subdiscoidal vein (with M_3 caudad of M); the transverse median vein of the forewings ($M_4 + Cu_1$) a long crooked vein, longer than the first transverse cubitus (r-m and R_5); three submarginal cells present in the front wing. In the hind wing a trace of the discoidal vein (m and M_2) may be seen, arising from the point of union of the cubital, median, and transverse median veins, but there is no trace of the apical section of the anal vein; only a few (9 or 10) costal hooks present. Forewings without a distinct preaxillary excision. Antennae of the male composed of 13 distinct segments. Mouth parts primitive, without an elongate retractile tongue, with 6 segmented maxillary and 4-segmented labial palpi....**Euparagiinae.**

BB. Anal lobe of the hind wings a small circular or oval flap, much less than one-half the length of the submedian cell (cell $M_3 + Cu + Cu_1$). In the forewings the second discoidal cell (M_3) wedge-shaped, narrowed or often pointed at base, its cephalo-distal angle not greatly produced toward the wing apex; the section of the discoidal vein between the 1st recurrent and the subdiscoidal veins (M_3 cephalad of m) transverse

[2] This key does not distinguish between the subfamilies Zethinae, Eumeninae, Stenogastrinae, Epiponinae, Rhopalidiinae, and Polistinae, as these groups are not treated in the present paper. Their characters are stated by Bequaert in his "Revision of the Vespidae of the Belgian Congo," *Bull. Amer. Mus. Nat. Hist.*, vol. 39 (1918), pp. 13–17.

[3] In reality, in all the Masaridinae, it is the apical section of the anal vein that is lost, and at least a trace of the discoidal vein is preserved. This, however, is not apparent from inspection; any one examining the wings casually would take the reverse to be the case. An explanation of the true condition is to be found under the description of the wings of Masaridinae.

or somewhat oblique in position, always shorter, often greatly shorter than the first recurrent vein (M_{3+4}), and forming an angle of 180° or *less* with the section of the discoidal vein caudad of the subdiscoidal vein (M_3 caudad of m); the transverse median vein short and straight, often almost lacking, always shorter than the 1st transverse cubital vein (r-m plus R_5). In the hind wings there is usually no trace of the discoidal vein (m and M_2), but in Gayella it is a fully formed vein, inserted far apicad of the transverse median vein (M_3); apical section of the anal vein always present, usually only as a trace; numerous costal hooks (20 or more) usually present.

C. In the hind wings apparently no trace of the discoidal vein (m and M_2) is present, and only trace of the apical sections of the radial, cubital, and anal veins[3] (R_5, R_{4+5}, 1st A). Mouth parts (except in *Paragiini*) specialized, with a retractile ligula which is often greatly elongate, and showing progressive reduction in the number of palpal segments ..... **Masaridinae.**

CC. In the hind wings the discoidal vein (m and M_2) is present and fully formed, arising from cubitus far apicad of the submedian vein. Mouth parts primitive, the ligula not elongate, the labial palpi 4-segmented and the maxillary palpi 6-segmented (figs. 4, 97) ..... **Gayellinae.**

AA. Transverse median vein of the hind wings (M_3) angled for the reception of the base of the discoidal vein (m) which is almost invariably a fully formed vein, or at least a distinct indication of the discoidal vein and the apical section of radius, cubitus, and the anal vein (R_5, $R_{4+5} + M_1$, m and M_2, 1st A) in the hind wings and these very generally all well formed veins. Forewings with 3 submarginal cells; the second discoidal cell (M_3) ordinarily wedge-shaped, pointed at the base and broadly truncate at apex. It varies somewhat from this condition but not greatly, being always strongly narrowed at base; while the apex may be somewhat sinuate, it is never greatly extended toward the wing apex; anal lobe of the hind wings very short and circular, oval or wanting.

B. Forewings with the second and third submarginal cells each receiving a recurrent vein (vein M_2 arising opposite the cell R_4, and vein M_{3+4} rising opposite the cell R_5) ..... **Raphiglossinae.**

BB. Forewings with the second submarginal cell receiving both recurrent veins (veins M_2 and M_{3+4} both arising opposite the cell R_5).

C. Posterior lobe of the hind wings present; preaxillary excision, if present, a mere undulation or shallow notch; the apical section of the anal vein not strongly curved caudad, the hind wing not subpetiolate (fig. 98) ..... **Zethinae. Eumeninae, Stenogastrinae, Epiponinae, Rhopalidiinae, Polistinae.**

CC. Anal lobe of the hind wing wanting; preaxillary excision[4] present, deep, the apical section of the anal vein strongly curved caudad; the hind wings subpetiolate, by reason of contraction of the anal area (fig. 99) ..... **Vespinae.**

[4] The preaxillary excision is a notch at the apex of the 1st anal vein of the hind wing; it is not the notch that cuts off the anal or posterior lobe, when present. Its significance is discussed in a forthcoming paper by the present writer on the wings of Hymenoptera.

A Working Key for Identifying the Genera of EUPARAGIINAE and MASARINAE[5]

(This key does not pretend to present the natural relations of the genera.)

1. Abdomen strongly petiolate, the first segment elongate, formed as in *Zethus* ..... **Plesiozethus** and **Paramasaris** Cameron.[6]
   Abdomen sessile, or the short first segment with a small anterior neck, but not at all Zethus-like 2
2. Forewings with cells R_1 and R_5 separate (3 closed submarginal cells) ..... **Euparagia** Cresson.
   Forewings with cells R_1 and R_5 coalesced (2 closed submarginal cells) 3
3. The first abdominal segment with an anterior neck therefore somewhat petiolate ..... **Ceramiopsis** Zavattari.
   First abdominal segment broad and sessile, as in *Vespa* 4
4. Postscutellum not covered by the scutellum, but produced caudad and bifid at apex ..... **Masaris** Fabrians.
   Postscutellum rounded and more or less covered by the scutellum 5
5. Sides of abdomen margined, serrate, venter concave; wings plaited longitudinally as in *Vespa* ..... **Celonites** Latreille.
   Sides of abdomen not margined, venter convex or nearly flat; wings longitudinally plaited only in *Quartinia* 6
6. Tegulae short, ovate or semicircular, scalelike, not covering the base of the scutellum; clypeus produced anteriorly, its margin truncate, in the females somewhat rounded 11
   Tegulae elongate and usually acute posteriorly, covering the base of the scutellum; clypeus emarginate or trilobed at apex 7
7. Clypeus with its apical border trilobed; m = eu opposite $M_4 + Cu_1$ ..... **Jugurtia** Saussure.
   Clypeus with its apical border emarginate 8
8. In the forewings the mediocubital cross-vein (basal vein) attached opposite to or basad of $M_4 + Cu_1$ (submedian vein); third ventral segment of males unarmed; larger spur of posterior tibiae not always bifid 9
   In the forewings the mediocubital cross-vein attached to M_4 far apicad of $M_4 + Cu_1$; anterior trochanters of the male unarmed; third ventral segment of the male with a process; larger spurs of posterior tibia bifid ..... **Pseudomasaris** Ashmead.
9. Anterior trochanters of the male armed with a prominent claw or lamella; apical segments of the antenna of the females somewhat incrassate, but not forming a distinct ovate club; habitat South America ..... **Trimeria** Saussure.

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[5] The synoptic tables which follow later are intended to suggest the natural relationships of the genera. They are not readily applicable for purposes of identification, and I have therefore prepared this artificial identification key, which I think may be used by any one easily and with certainty as to its meaning. At the end is a short working key to North American genera.

[6] Cameron distinguishes between these two genera on the grounds that in *Plesiozethus* there are only 2 closed submarginal cells, both M_{3+4} and M_2 arising from the cell R_{4+5}, while in *Paramasaris* cells R_4 and R_5 are separate; M_{3+4} arising from cell R_5 and M_2 from cell R_4. Zavattari maintains that Cameron is wrong, and that both genera show the latter condition. In that eventuality it is probable that they will have to be united under the name *Paramasaris*.

Anterior trochanters of the male unarmed; apical segments of the antenna of the female forming a distinct ovate club; habitat South Africa and southern Europe 10

10. Pedicel greatly enlarged, globose, nearly as large as the scape; antennae not as long as the distance between the eyes; size small, 4 mm. ..... **Quartinia** Gribodo.

Pedicel not enlarged nor globose, less than one-half as long as the scape; antennae of the male much longer than the distance between the eyes; size large, 7 mm. or over..... **Masariella** Brauns.

11. Scutellum semicircular, very strongly elevated, its top flat, the sides abrupt, venter of the male with a process on the second segment, and with 8 exposed segments, the seventh small, simple, the eighth with a basal process; Australian 12

Scutellum elongate and more or less obtusely pointed behind, not strongly elevated, but moderately convex, or flattened on top, its sides not abrupt, venter of the male usually unarmed, with 7 exposed segments, the seventh large and truncate or subtruncate at apex; eyes emarginat at least slightly, usually deeply; European or African 13

12. Eyes emarginate; parapsidal furrows absent.... **Metaparagia** Meade Waldo.

Eyes not emarginate; parapsidal furrows distinct..... **Paragia** Shuckard.

13. Eyes deeply emarginate; venter of male unarmed 14

Eyes very broadly and shallowly emarginate, scarcely more than sinuate; third ventral segment of the male armed with one or two tubercles; middle tibiae with one apical spur; antennae of the sexes dissimilar, those of male with the apical segment elongate, tapered and recurved; mandibles of the male without a large basal tooth, clypeus of male longer than broad; anterior trochanters of male produced at apex into an elongate scale ..... **Ceramioides** Saussure.

14. Middle tibiae with a single apical spur; antennae of the sexes dissimilar, those of the male rolled at apex, the last segment much longer than broad; mandibles of male without a large basal tooth; clypeus of the male longer than broad; anterior trochanters of male unarmed ..... **Paraceramius** Saussure.

Middle tibiae with two apical spurs; antennae of the sexes similar, not recurved at apex, the last segment broader than long; mandibles of the male with a very large tooth at base; clypeus of the male broader than long; anterior trochanter of the male produced and acute at apex ..... **Ceramius** Latreille.

Key to the Genera of EUPARAGIINAE and MASARIDINAE Known to Occur in North America

1. Forewing with cells R_4 and R_5 separate (3 submarginal cells) 2

Forewing with cells R_4 and R_5 coalesced (2 submarginal cells) ..... **Pseudomasaris** Ashmead

2. Abdomen sessile ..... **Euparagia** Cresson

Abdomen petiolate, as in *Zethus* ..... **Paramasaris** Cameron and **Plesozethus** Cameron[6]

New Subfamily **Euparagiinae**

Genus **Euparagia** Cresson

1902. *Euparagiini*, tribe Ashmead. Canadian Entomologist, vol. 34, p. 218.
1879. *Euparagia* Cresson. Proceedings of the Academy of Natural Sciences of Philadelphia, Entomological Section, vol. 6, p. vi.
1904. *Plesiomasaris* Cameron. Transactions of the American Entomological Society, vol. 30, p. 267.
1905. *Odynerus* Cameron. Transactions of the American Entomological Society, vol. 31, p. 380.
1909. *Psiloglossa* Rohwer. Entomological News, vol. 20, p. 357.

Type.—Euparagia scutellaris Cresson; genus monobasic.

Habitat.—Southwestern North America.

♂. Head wider than the thorax; eyes large, nearly 3 times farther apart than are the posterior ocelli, emarginate; an inconspicuous tubercle between the antennae; clypeus longer than broad, its anterior margin medially produced and bidentate; temples margined posteriorly by a fine carina, reaching to the mandibles; occiput bordered above by a second fine carina, caudad of the one bordering the temples; mandibles ending in two nearly equal teeth; ligula broad, not retractile, flat, its apex deeply acutely notched, but little longer than the paraglossae; labial palpus long, about as long as the stipes, 4-segmented; maxillary palpus longer than the stipes, 6-segmented. Antenna consisting of 13 segments, the scape about twice as long as the pedicel, equal to segment 3, segments 3 to 6 longer than broad, seventh about equal in length and breadth, 8 to 13 broader than long, together slightly fusiform.

Humeri weakly prominent; parapsidal furrows wanting; tegula semicircular, scalelike, not covering the base of the scutellum, its outer margin entire; angles of propodeum marked only by a ridge.

In the forewing m-cu attached to the junction of Cu_1 and M_4. Tarsal claws simple; apex of the front trochanter with a long inferior claw; anterior femur somewhat contorted, with a prominent inferior tooth at base; the tibia normal, about as long as the tarsus, with an illy formed strigil; the metatarsus a little shorter than the following 4 segments together, the fourth segment as long as broad; middle femur unarmed, the apical half of the under surface flat; the tibia unarmed, a little compressed, sometimes bearing a single apical spur, in other cases with two, a trifle shorter than the tarsus; metatarsus two-thirds as long as the remaining segments together, the fourth segment as long as broad; posterior tibial spur acute, the apical half of the inner margin oblique and armed with 3 large basal and 2 minute apical teeth; the tibia about four-fifths as long as the tarsus; the metatarsus a little shorter than the following segments together.

Abdomen sessile, unarmed, the venter flat, the last ventral segment nearly semicircular. Squama forming an acute upturned hook, not fused with the ramus; sagitta of irregular shape, bearing an apparently movable oval process, the apical part of which is scarcely chitinized and bears a patch of setae; uncus broad, flat, obtuse, not barbed at base, but with a minute tooth about the middle of either side.

♀. Eyes not so large as in the male, their emarginations less sharp, the face, between the eyes, much broader than in the male, the bases of the antennae much more distant from the eyes; clypeus less deeply bifid at apex than in the male; mandibles blunt; with a tooth on the inner margin before the apex; antennae as in the male, but 12-segmented.

Trochanter, femora and other segments of the legs simple. The middle tibia show sometimes one and sometimes two apical spurs.

The venter is less flat than in the male.

The generic identity of *Psiloglossa simplicipes* with *Euparagia* was suggested to me by Dr. Bequaert. Acting upon this suggestion, we together established the certainty to our mutual satisfaction.

Key to the Species of EUPARAGIA

Vertex with two prominent smooth tubercles behind the ocelli; vertex and front coarsely, irregularly punctate; pronotum coarsely punctured; mesonotum rugose; posterior face of propodeum with transverse rugae at the angles, almost smooth in the middle, but with a few scattered irregular large punctures, its lateral faces smooth medially, finely punctate below and slightly aciculate above and behind; clypeus of the female with minute punctuations and scattered coarser punctures ..... **maculiceps** Cameron.

Vertex simple without tubercles, vertex and front uniformly granular punctate; pronotum finely punctate; mesonotum evenly, finely granular-punctate; propodeum closely evenly punctulate; clypeus of the female longitudinally aciculate ..... **maculifrons** Cresson.

Euparagia maculiceps (Cameron)

1904. *Plesiomasaris maculiceps* Cameron, ♂. Trans. Amer. Ent. Soc., vol. 30, p. 267.

1905. *Odynerus simplicipes* Cameron, ♂. Trans. Amer. Ent. Soc., vol. 31, p. 380. (See Meade Waldo. Ann. and Mag. Nat. Hist., [8], vol. 14 (1914), p. 404.

1909. *Psiloglossa simplicipes* Rohwer, ♀. Ent. News, vol. 20, p. 357.

New Mexico: Las Cruces, August 31, 1 ♀ at flowers of *Solidago canadensis*, type of *simplicipes* Rohwer (C. H. T. Townsend).

Mexico: [types of *maculiceps* Cameron and *simplicipes* Cameron, British Museum]; Guerrero, 3000 feet (Godman & Salvin), [British Museum, recorded by Meade Waldo].

Euparagia scutellaris Cresson

Figures 1, 2, 11, 14, 26, 27, 42, 68–74, 93, 100

1879. *Euparagia scutellaris* Cresson, ♂, ♀. Proc. Acad. Nat. Sci. Phila., Ent. Sec., vol. 6, p. vi.

♂. Stout, form somewhat Oxybelus-like. Black, the following parts amber yellow: clypeus except borders, mandibles except base and apex, spot at summit of each eye, dorsal surface of pronotum, except postero-lateral margins, tubercles, tegulae at base and at apex, spot in front of scutellum, large pentagonal spot at apex of scutellum, claw on front trochanter, apical third of anterior and tips of middle and posterior femora, tibiae except for irregular reddish and brown blotches, metatarsi, apical border of dorsal segments 1 to 6 laterally dilated, and on segments 2 to 6 also medially dilated, and a median spot on each of ventral segments 2 to 7; the four apical segments of all tarsi reddish brown; flagellum except base of 1st segment, reddish brown, cream colored beneath. Head and thorax silvery sericeous, mesotergum brown-sericeous, abdomen somewhat yellowish sericeous toward the apex.

Head closely, clypeus more sparsely, regularly and rather coarsely punctulate; dorsum similarly sculptured; scutellum with a longitudinal fossa on each side; pleurae more finely and sparsely punctured than the dorsum; propodeum with a median channel, shallowly rugosely punctate; the postero-lateral angles forming a ridge but not carinate. Length, 7 mm.

♀. Colored as in male except that the entire head, except spot above each eye, the antennae, legs, except knees and venter, are black, the mandibles piceous. The clypeus is longitudinally aciculate. Otherwise like the male.

Nevada: 2 ♂, 2 ♀ [types, American Entomological Society].

California: Claremont, 3 ♂, 1 ♀ (C. F. Baker), [Pomona College, Cornell University, Jos. Bequaert]; mountains near Claremont, 1 ♂ (C. F. Baker), [Pomona College]; Santa Clara Co. (C. F. Baker), [Cornell Univ.]; Sobre Vista, Sonoma Co., 1 ♀, May 12, 1910 (J. A. Kusche), [Calif. Acad. Sci.].

Plesiozethus Cameron

?1901. *Paramasaris* Cameron. Transactions of the American Entomological Society, vol. 27, p. 312.

1904. *Zethoides* Cameron. Transactions of the American Entomological Society, vol. 30, p. 93 (not Fox).

1905. *Plesiozethus* Cameron. Entomologist, vol. 38, p. 269.

1906. *Metazethoides* Schulz. Spolia hymenopterologica, p. 213.

1907. *Plesiozethus* Cameron. Entomologist, vol. 40, p. 62.

1912. *Plesiozethus* Zavattari. Archiv für Naturgeschichte, vol. 78, pt. A, no. 2, p. 62.

Type.—Plesiozethus flavolineatus Cameron; genus monobasic.

Habitat.—Panama; Colombia.

I have not seen a specimen of this genus, and consider its position very doubtful. I am even doubtful that it is a masarine wasp. Zavattari has pointed out the probable identity with *Paramasaris,* maintaining that Cameron is incorrect in stating that *Plesiozethus* has only 2 submarginal cells.

List of Species of PLESIOZETHUS

flavolineatus Cameron, ♂, ♀. Panama; Colombia.

1904. *Zethoides flavolineatus* Cameron, ♂. Transactions of the American Entomological Society, vol. 30, p. 93.

1905. *Plesiozethus flavolineatus* Cameron. Entomologist, vol. 38, p. 269.

1906. *Metazethoides flavolineatus* Schulz. Spolia hymenopterologica, p. 213.

1907. *Plesiozethus flavolineatus* Cameron. Entomologist, vol. 40, p. 62.

1912. *Plesiozethus flavolineatus* Zavattari, ♂, ♀. Archiv für Naturgeschichte, vol. 78, pt. A, no. 2, p. 64 (description of female).

Paramaşaris Cameron

1901. *Paramasaris* Cameron. Transactions American Entomological Society, vol. 27, p. 311.

?1904, 1905. *Zethoides, Plesiozethus,* Cameron.

Type.—Paramasaris fuscipennis, Cameron, genus monobasic.

Habitat.—New Mexico.

As already indicated, if Zavattari is correct in his characterization of *Plesiozethus,* it is probably identical with this genus.

Paramasaris fuscipennis Cameron

1901. *Paramasaris fuscipennis* Cameron, ♀. Trans. Am. Ent. Soc., vol. 27, p. 312.

"Black, covered with a white pile; the underside of the antennae brownish, the apex of the petiole and of the second segment pallid yellow; the wings fusco-hyaline; the radial cellule smoky; the stigma and nervures black. ♀. Length, 7 mm.

"Antennae shorter than the thorax; the joints of the club clearly separated, the thickening commencing from the fourth joint. The front, vertex and the upper part of the eye incision distinctly punctured; the clypeus is shining and less strongly and closely punctured; its apex is distinctly depressed and the sides are roundly narrowed. The sides of the thorax are more densely covered with a silvery pile

than is the upper part; the pro- and mesothorax are closely and distinctly punctured; on the apex of the mesonotum, in the center, are two short deep furrows, which are deep, and are wider at the apex than at the base. The scutellum is more strongly and somewhat more widely punctured; its basal furrow bears 7 stout longitudinal keels. The median segment, except on the base and the lower part of the pleurae, bears large, round, deep punctures; the center in the apex is smooth, shining and depressed; down the middle of the segment is a narrow, transversely striated band; the transverse striae being weaker at the base, and at the apex they are stouter and fewer in number. The base of the prothorax is keeled all round; behind this keel is another less distinct one, which curves backwards above to near the end of the pronotum; on the pleurae the space between the two keels is striated. Mesopleurae obscurely and sparsely punctured; in front of the centre are 7 large foveae, the upper 4 are round and deep and the uppermost is in front of the others; the lower ones are larger and deeper, are separated by stout keels, and are placed somewhat in front of those in the middle so that the row of foveae forms a curve; the apex is bordered by a narrow crenulated furrow. On the lower half of the base of the metapleurae are four deep foveae separated by stout keels; on the upper half, behind the middle, is a row of smaller foveae; the apical half is irregularly closely reticulated. Legs pruinose, black; the tarsi with a fuscous tint; the calcaria are testaceous. The radial cellule is distinctly appendiculated, the appendicular cellule being longer than broad; the second cubital cellule at the top is not one-fourth of the length of the third, at the bottom, half its length; the first recurrent nervure is received near the base, the second close to the middle of the cellule; the transverse basal nervure is interstitial. Abdomen pruinose; the petiole distinctly longer than the second segment and punctured; the punctures at the base more pronounced than elsewhere; the apex is depressed and narrowed; near the base of the narrowed neck is a row of depressed furrows."

New Mexico: "Santa Fé Mts." (I have not been able to learn of any mountains bearing this name.)

Subfamily **Masaridinae**

Synoptic Table of the Tribes of MASARIDINAE

Glossae not retractile, short, scarcely exceeding the length of the paraglossae, the membranous part much shorter than the stipes and quite broad; the maxillary palpus 6-segmented, of normal length, the labial palpus 4-segmented; antenna of the male incrassate toward the apex but without a club....**Paragiini.**

Glossae retractile, very elongate, far exceeding the length of the paraglossae, at least as long as the stipes and usually many times as long, narrow and forming a sucking tube; maxillary palpus reduced in size, at most 4-segmented (except in *Ceramiopsis*, where it is 6-segmented), often reduced to a mere tubercle; labial palpus consisting of from 1 to 4 segments; antenna of the male with the apical segments often fused into an indistinctly segmented club .....**Masaridini.**

Synoptic Table to the Genera of the Tribe PARAGIINI

Eyes emarginate; parapsidal furrows absent ..... **Metaparagia** Meade Waldo.
Eyes not emarginate; parapsidal furrows distinct ..... **Paragia** Shuckard.

Synoptic Table of the Genera of the Tribe MASARIDINI

A. Maxillary palpus consisting of 6 segments, the labial of 4 ..... **Ceramiopsis** Zavattari.

AA. Maxillary palpus consisting of 4 segments, the ligula beneath with many transverse scale-like appendages.

B. Middle tibia with 2 apical spurs, shorter than the first 4 segments of the tarsus united, the fourth segment longer than broad; antenna of the male like that of the female, gradually incrassate toward the apex, the penultimate segment much broader than long, the ultimate segment short, conical, not hooked; mandible of the male slender, acute, with two serrations on the inner margin somewhat removed from the apex and a strong basal tooth; clypeus of the male broader than long; second ventral segment of the male unarmed; squama slender and acute;[7] the uncus reduced to a small basal piece,[7] not readily observable; the sagitta and the volsella much enlarged and fused with those of the opposite side[7] ..... **Ceramius** Latreille.

BB. Middle tibia with only 1 apical spur,[8] longer than the first 4 tarsal segments together,[8] the fourth segment broader than long; antenna of the male unlike that of the female, the penultimate segment on its outer margin much longer than broad, the ultimate segment long, digitiform, forming a hook; mandible of the male obliquely truncate with 3 strong apical teeth but no basal tooth; clypeus of the male longer than broad; second ventral segment of the male unarmed; squama clavate;[8] uncus elongate;[8] sagitta and volsella small and not united with those of the opposite sides[8] ..... **Paraceramius** Saussure.

BBB. Twelfth segment of the antenna of the male forming a large hook; clypeus of the male longer than broad; mandible of the male obliquely truncate and terminating in 3 or 4 short teeth; abdominal segments constricted at base, the second ventral segment of the male bearing a tubercle ..... **Ceramioides**[9] Saussure.

AAA. Maxillary palpi consisting of 2 or 3 segments.

B. Scape elongate, cylindrical or curved, more than twice as long as the pedicel.

C. Antenna of the female composed of 7 distinct segments, short; that of the male composed of 12 distinct segments, strongly incrassate but not forming a globular club, convex beneath ..... **Jugurtia** Saussure.

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[7] These characters are drawn from an examination of the male of the type species, *fonscolombei*, only.

[8] These characters are drawn from an examination of the male of only one species, *lusitanicus*, the genotype.

[9] I have not seen the genotype of *Ceramioides*, so state the characters indicated by Saussure.

CC. Antenna of the female composed of 12 segments, incrassate apically, but not forming a club; that of the male elongate, reaching the scutellum, segments 3 to 6 linear, 7 to 10 incrassate, concave beneath; 11 and 12 scarcely separable ..... **Masariella** Brauns.

BB. Scape and pedicel both globular, the latter at least one-half as long as the former.

C. Venter convex ..... **Quartinia** Gribodo.

CC. Venter flat or concave ..... **Celonites** Latreille.

AAAA. Maxillary palpus consisting of but a single very short segment, a mere tubercle easily entirely overlooked.

B. Middle tibia with 2 apical spurs, spur of posterior tibia not bifid; labial palpus of the male 4-segmented, the apical segment very short; seventh ventral segment with a median apical notch, not deep and by no means reaching to the sixth segment; antenna of the male long, the third, fourth, and fifth segments linear, the fifth somewhat thickened, the sixth more strongly so, the seventh to twelfth segments almost indistinguishably fused into a club which is convex beneath; claws with a small median tooth; last dorsal segment, seen from the side, acute, from above ending in 2 stout teeth ..... **Masaris** Fabricius.

BB. Middle tibia with 1 apical spur; spur of posterior tibia bifid; labial palpus 1- to 3-segmented; apical margin of seventh ventral segment of the male either truncate or with a very deep quadrate notch reaching to the sixth segment; antenna of the ♂ variously formed; claws simple; last dorsal segment, seen from the side obtusely curved, or truncate; in the latter case the truncature is margined by two strong inferior and two strong superior teeth, in the former case there are no teeth, but, seen from above, it is weakly notched at apex.

C. Antenna of the male and of the female dissimilar, that of the male much the longer, the apex in each sex always with a club, and at least the first segment of the flagellum and usually more, much longer than broad; labial palpus in the male consisting of from 1 to 3 segments, in the latter case the last segment shorter than the preceding; in the female consisting of three segments, the first long and flattened, the second short, the third much longer than the second, falcate, very slender and acute, and ending in two stout spines; the last dorsal segment is much curved ventrad, its apical portion vertically truncate, the truncature bordered above and below by a pair of strong teeth or tubercles, the latter placed closer together than the former pair; apical margin of the seventh ventral segment with a very deep, usually rectangular emargination, reaching basad to beneath the sixth segment; squama always lamelliform and obtuse, never ending in a spine or hook; uncus never broad and flat, but slender and usually acute, and often decurved at tip ..... **Pseudomasaris** Ashmead.

CC. Antenna of the male and of the female similar, except that that of the latter has 11, of the former, 12 segments, but slightly incrassate, the segments of the flagellum all as broad and mostly broader

than long; labial palpi 3-segmented in both sexes;[10] last dorsal segment hood shaped, rounded to meet the venter, without apical teeth or truncature, but slightly transversely emarginate at apex; apex of the seventh ventral segment truncate; uncus very broad and strongly depressed; squama ending in a sharp, strongly decurved hook ..... **Trimeria** Buysson.

Genus **Paragia** Shuckard

Figures 3, 13, 24, 25, 43–45, 75, 76, 91, 92, 94, 101.

♀. General form like *Vespa*. Head large; the occiput immargined; the temples broad, immargined, eyes not incised, but the inner margins sinuate, reaching the mandibles, separate from one another above by a distance equal to their own length; ocelli close, in a small triangle which is slightly broader than high; front moderately prominent; clypeus moderately prominent, the anterior margin produced and truncate; labrum short, bilobed; mandibles short and stout, the inner margin with two teeth.

The ligula is short and not retractile, composed of the two strap-like glossae, which are about the length of the labial palpus, strongly divergent, united only for a short distance at their bases. The paraglossae are similar in appearance to the glossae and but little shorter. The glossae and paraglossae are all tipped with a chitinous button, such as is often found in Eumeninae. The dorsal hind margin of the glossa bears a series of elongate and very broadly transversely flattened setae, analogous to the scales found in *Ceramius* and *Paraceramius*, and the anterior dorsal margin is fringed with smaller and less conspicuous setae, somewhat flattened in the opposite diameter. At the base of the glossa, mesad of the paraglossae is a membranous lobe armed with a group of minute tubercles, and between the two of these, in the median line, is a heavily chitinized tongue-shaped piece, the tip of which is turned upward; the labial palpus is 4-segmented, non-elongate, the first segment stout and widened at apex, the last half as long. Between the two palpi, in the median line, an anterior tongue-like extension of the heavily chitinized mentum and submentum is thickly set with sensory setae. The point of this process is very acute, turned upward and may be distinctly seen from the dorsal surface. On the dorsal side at the base of the glossa and bearing this at their apex are two chitinized plates, with a partly lateral, partly dorsal surface, joined at their bases, and formed like a letter V with expanded arms. Laterad of these, and somewhat enclosing them, is on each side a chitinized roughly triangular piece, with acute apex situated at the bases of the paraglossae. The inner margins of these two pieces are fringed with a double comb of spines; a chitinized band on either side between these pieces passes forward beneath the combs to near their apices, then ventrad between the glossae and paraglossae articulating on the ventral

[10] I have seen only the male, but Saussure states that they are 3-segmented in the female.

surface with the tongue-shaped chitinized piece which has been described as lying at the base of the glossae. The maxillae present features of considerable interest. The cardo is of the normal form, bent at right angles to the stipes; the inner surface of the latter meets the ventral in a sharp ridge, crested apically with a comb of bristles. The palpi are 6-segmented, the last two segments together equalling the third in length. The apical portions are turned, so that from a strictly ventral view one observes the edges of the lobes, rather than their surfaces. From a somewhat external aspect, opposite the base of the palpus, there is a triangular sclerite, projecting dorso-entad, and bearing a few spines. This is ordinarily interpreted as the lacinia. Very closely and broadly attached to its base is a large lobe extending cephalad, and to the inner upper margin of this is attached a second narrow lobe. The latter has on its upper margin a still narrower third lobe. These three lobes seem to correspond to what usually together pass for the mesal lobe of the galea, but this insect would suggest that they may really be part of the lacinia. From an inner view of the maxilla there is seen attached to the apex of the cardo a prominent but scarcely chitinized oval lobe, margined dorsally with a thick fringe of bristles, and with a few longer setae on the lower margin. This lobe is present in all Masaridae that I have examined, and may represent the basal lobe of the galea. Apicad of it is a small ear-shaped lobe, very prominent because of being more heavily chitinized than the other parts, and which probably is the outer lobe of the galea.

The scape is elongate, slightly compressed; the pedicel very short; the flagellum is inerassate toward the apex, but without forming a club, composed of 10 distinct segments, the first almost equal in length to the following 4 united.

Humeri prominent, slightly angled; parapsidal furrows distinct; the tegula small, scale-like, oval, the outer margin entire, by no means reaching the base of the scutellum; this is prominently elevated, but with its surface flat, covering the postscutellum; propodeum sloping directly to its apex, i.e., without dorsal surface, and without any lateral angles or even ridges.

Cells R_4 and R_5 united (i.e., two closed submarginal cells) and embracing both veins M_{3+4} and M_2; m-cu arising from Cu_1, which at that point is deflected to meet M_4. Hind wing with a small but distinct anal lobe. Anterior trochanter unarmed; all the segments of the legs with regular convex or slightly flattened surface, without ridges or tubercles; spur of anterior tibia broad, acute, with a tooth on its convex margin; the middle tibia has two apical spurs; the larger spur of the hind tibia has its apex obliquely tridentate, the margin basad of the inner tooth pubescent; all claws are large and with a large sharp tooth at base.

The abdomen is like that of a *Vespa*.

♂. General appearance of a Monobia or Eumenes; head transversely rectangular, the temples broad, not margined behind; ocelli in a low triangle, distant from the eyes; the latter with their inner margins sinuate but not emarginate; clypeus prominent, with anterior margin

strongly produced and abruptly truncate, concealing or nearly concealing the small labrum; mandibles broad, with two large teeth before the apex. Antennae long and slender, of 12 segments, the scape long, the third segment still longer, the eleventh and twelfth segments sometimes incised beneath (tricolor).

Humeri rounded; parapsidal furrows distinct, scutellum elevated, flattened on top; propodeum slightly concave, the lateral angles rounded, without tooth above (genotype) or with a blunt tooth in some.

Forewing with two submarginal cells; m-cu attached to Cu_1, which is at that point deflected caudad a very short distance to join M_4. Anterior trochanter unarmed; all femora and tibia with even surfaces; middle tibia with two apical spurs; posterior tibial spur as in the females; claws large; much curved, with a strong tooth beneath near the base.

Abdomen shaped as in *Vespa,* the last dorsal segment ending in two lobes, with a shallow notch between; second ventral segment with an acute median prominence behind.

Habitat.—Australia.

List of Species of PARAGIA

australis Saussure, ♂, ♀. Australia.
bicolor Saussure, ♂, ♀. Australia.
bidens Saussure, ♂. Australia.
calida Smith, ♂. Australia.
concinna Smith, ♀. Australia.
deceptor Smith, ♀. Australia.
decipiens Shuckard, ♂, ♀. Australia.
excellens Smith, ♂, ♀. Australia.
hirsuta Meade Waldo, ♂. N. Queensland.
1911. *Paragia hirsuta* Meade Waldo, ♂. Ann. and Mag. Nat. Hist., (8), vol. 8, p. 749.
magdalena Turner, ♀. Queensland.
1908. *Paragia magdalena* Turner. Trans. Ent. Soc. London, (1908), p. 89
moroso Smith, ♀. Australia.
nasuta Smith, ♀. Australia.
odyneroides Smith, ♂. Australia.
perkinsi Meade Waldo, ♀. Queensland.
1911. *Paragia perkinsi* Meade Waldo, ♀. Annals and Magazine of Natural History, (8), vol. 8, p. 750.
praedator Saussure, ♀. Australia.
saussurii Smith, ♀. Australia.
sobrina Smith, ♀. Australia.
tricolor Smith, ♂, ♀. Australia.
venusta Smith, ♀. Australia.
vespiformis Smith, ♂, ♀. Australia.
walkeri Meade Waldo, ♂. Australia.
1910. *Paragia walkeri* Meade Waldo, ♂. Annals and Magazine of Natural History, (8), vol. 5, p. 33.

Key to the Species

Meade Waldo: Ann. and Mag. Nat. Hist., (8), vol. 5 (1910), p. 31. The following species not included: *australis, bicolor, hirsuta, perkinsi.*

Genus **Metaparagia** Meade Waldo

Paragia auctores, pars.

1911. *Metaparagia* Meade Waldo. Annals and Magazine of Natural History, (8), vol. 8, p. 748.

This genus I have not seen.

Type.—Paragia pictifrons Smith, by original designation.

Species of METAPARAGIA

doddi Meade Waldo, ♀. N. Queensland.

1911. *Metaparagia doddi* Meade Waldo, ♀. Ann. and Mag. Nat. Hist., (8), vol. 8, p. 748.

maculata Meade Waldo, ♂, ♀. Australia.

1910. *Paragia maculata* Meade Waldo, ♂, ♀. Ann. and Mag. Nat. Hist., (8), vol. 5, p. 32.

1911. *Metaparagia maculata* Meade Waldo. *Loc. cit.*, (8), vol. 8, p. 749.

pictifrons (Smith) Meade Waldo, ♀. Australia.

1857. *Paragia pictifrons* Smith.

Key to Species of METAPARAGIA

Meade Waldo. Ann. and Mag. Nat. Hist., (8), vol. 8 (1911), p. 749.

Genus **Ceramiopsis** Zavattari

1910. *Ceramiopsis* Zavattari. Annali del Museo civico di storia naturale, Genova, (3), vol. 4, p. 533.

1912. *Ceramiopsis* Zavattari. Arch. f. Naturgeschichte, vol. 78, pt. A, no. 2, p. 60. Figure of abdomen and description.

This genus I have not seen.

Type.—Ceramiopsis gestroi Zavattari, genus monobasic.

Habitat.—Brazil.

Species of CERAMIOPSIS

gestroi Zavattari, ♀. Brazil.

1910. *Ceramiopsis gestroi* Zavattari, ♀. Annali del Museo civico di storia naturale, Genova, (3), vol. 4, p. 533.

1912. *Ceramiopsis gestroi* Zavattari, ♀. Arch. f. Naturgeschichte, vol. 78, pt. A, no. 2, p. 60.

Genus **Ceramius** Latreille

Figures 9, 12, 15

1904. *Euceramius* Dalla Torre. Genera Insectorum, fasc. 19, p. 5.

♂. Head broad, quadrate; clypeus broader than long, produced medially and truncate; glossa retractile, but short, when fully extended but little longer than the stipes; both palpi 4-segmented; the maxillary palpus small.

Humeri rounded; parapsidal furrows present but not deep; tegula not elongate, scale-like and without coarse punctures, the outer margin entire; angles of propodeum entirely rounded.

Medio-cubital cross-vein attached to Cu_1; spur of anterior tibia flattened, arched, with a transparent upper margin and bifid tip; anterior trochanter alate at apex; front femur 3-sided, twisted; middle and hind femora and tibiae compressed, their surfaces regular: anterior and middle claws with a small median tooth, that of the hind claw minute; middle tibia with two nearly equal spurs; longer spur of hind tibia acute, simple.

Sixth sternite with a very deep median notch exposing a smooth and highly polished area of the seventh; the apex of the seventh produced into a thickened and truncate lobe.

Genitalia as described in the table and illustrated in figures.

The above characters are drawn from the type species. I have not seen a female.

In its genitalia this departs more radically from the usual type of the family than does any other genus which I have examined. The peculiar series of transverse erect scales beneath the ligula I have not observed elsewhere except in *Paraceramius*.

Type.—*Ceramius fonscolombei*.

Habitat.—Africa, Southern Europe, Caucasus.

Species of CERAMIUS[11]

beyeri Brauns, ♂, ♀. Cape Colony.

1903. Ceramius beyeri Brauns, ♂, ♀. Zeitsch. f. systemat. Hymenopterologie u. Dipterologie, vol. 3, p. 69.

caffer Saussure, ♀. Cape Colony (probably a variety of *lichtensteinii*).

capensis Saussure, ♀. Cape Colony.

[*capicola* Brauns, ♂, ♀. Cape Colony. See *Ceramioides*.]

caucasious Andre, ♂. Caucasus.

consobrinus Saussure, ♂, ♀. Cape Colony.

1913. *Ceramius consobrinus* Brauns, ♂, ♀. Entomologische Mitteilungen, vol. 2, p. 194. (First description of male.)

fonscolombei Latreille, ♂, ♀. Mediterranean subregion.

[*fumipennis* Brauns, ♂, ♀. Cape Colony. See *Ceramioides*.]

[11] Although these species all stand in literature under this genus, they many of them doubtless belong to *Ceramioides* or *Paraceramius*.

hispanicus Dusmet, ♂, ♀. Spain.

1908. *Ceramius hispanicus* Dusmet. Mem. Pri. Congr. Nat. Espan., p. 180.

karrooensis Brauns, ♂. Cape Colony.

1902. *Ceramius karrooensis* Brauns, ♂. Zeitsch. f. systemat. Hymenopterologie u. Dipterologie, vol. 2, p. 282; vol. 3, p. 68.

lichtensteinii Klug, ♂, ♀. Cape Colony.

1906. *Ceramius rufomaculatus* Cameron. Trans. South African Philos. Soc., vol. 16, pt. 4.

1913. *Ceramius lichtensteinii* Brauns. Entomologische Mitteilungen, vol. 2, p. 193, pl. 2, fig. 1.

var. *macrocephalus* Saussure.

1903. *Ceramius macrocephalus* Brauns, ♂, ♀. Zeitsch. f. systemat. Hymenopterologie u. Dipterologie, vol. 3, pp. 65, 68.

1903. *Ceramius lichtensteini* var. *macrocephalus* Brauns, ♂, ♀. Entomologische Mitteilungen, vol. 2, p. 193.

[*macrocephalus* Saussure. See *lichtensteinii* var. *macrocephalus*.]

oraniensis Saussure, ♂, ♀. Algeria.

peringueyi Brauns, ♀. Cape Colony.

1913. *Ceramius peringueyi* Brauns, ♀. Entomologische Mitteilungen, vol. 2, p. 194.

rex Saussure, ♀. Cape Colony. (Probably a variety of *lichtensteinii*.)

[*rufomaculatus* Cameron. See *lichtensteinii*.]

[*schulthessi* Brauns, ♂, ♀. Cape Colony. See *Ceramioides*.]

vespiformis Saussure, ♀. Cape Colony.

Genus **Paraceramius** Saussure

Figures 36, 102

♂. Head quadrate, not as broad as in *Ceramius;* clypeus elongate, not as squarely truncate as in *Ceramius;* the glossae retractile, elongate, forming a tubular ligula, with a peculiar series of transverse erect scales beneath, as in *Ceramius;* palpi as in *Ceramius.*

Humeri entirely rounded; parapsidal furrows wanting; tegula small, scale-like, without coarse punctures, the outer margin rounded, entire; angles of propodeum entirely rounded.

Venation as in *Ceramius.* Spur of anterior tibia as in *Ceramius* except that it ends in a lobe and a spine instead of two nearly equal spines; anterior trochanter simple, the femur with a sharp crest beneath; all claws with a large basal tooth; middle tibia with one apical spur; the larger spur of hind tibia with 3 short spines before its tip.

Sixth and seventh sternites as in *Ceramius.*

Genitalia as described in the table and illustrated in figure 8.

The above characters apply to *P. lusitanicus* (Klug). I have not seen a female.

The single spur on the middle tarsus, the difference in the spurs on the anterior and hind tarsi, the simple front trochanters, the great genitalic and other differences make it impossible to include this group any longer as a subgenus of *Ceramius.*

Habitat.—Korea, Southern Europe, Africa.

Species of PARACERAMIUS

koreensis Radoszkowski, ♀. Korea.
linearis Klug, ♂. Cape Colony.
lusitanicus Klug, ♂, ♀. Southern Europe.
var. *luteoclypeata* Dusmet, ♂. Spain.
1908. *Ceramius lusitanicus* var. *luteoclypeata* Dusmet. Mem. Pri. Congr. Nat. Espan., 1908, p. 180.
[*nigripennis* Saussure. See *Ceramioides.*]
spiricornis Saussure, ♂, ♀. France and Spain.

Genus **Ceramioides** Saussure

♂. Eyes very distant from each other and from the ocelli formed on the vertex, their inner margins very broadly and shallowly emarginate, but little more than sinuate; clypeus flat, longer than broad, its anterior margin produced and squarely truncate; mandibles rather broad and flat, two teeth on the inner margin before the apex, labial palpi 4-segmented. Antennae long and slender, of 12 segments, a very little widened before the apex, the eleventh segment longer than broad, the twelfth more than twice as long as the eleventh, tapered and recurved, forming an apical hook.

Humeri entirely rounded; parapsidal furrows weak anteriorly but forming two deep grooves near the middle line just before the scutellum; tegulae short, scale-like, not covering the base of the scutellum, impunctate; disc of scutellum flat, posteriorly broadly rounded, covering and concealing the rounded postscutellum; posterior face of propodeum small, flat, rounded into the sides below, but superiorly sharply truncate.

In the forewings m-cu inserted shortly basad of $M_4 + Cu_1$, Cu_1 at the point of insertion of m-cu turning caudad for a short way to meet M_4. Anterior trochanter produced at apex into an elongate scale, tibiae and femora with even surfaces except that the anterior femur is widened beneath before the middle; middle tibia with a single spur at apex; larger posterior tibial spur with two spines and a tooth on its margin toward the apex; claws with a small tooth on the inner margin at its middle.

Abdomen subcylindrical, flattened beneath, the second, third, and fourth dorsal segments somewhat constricted basally; the last dorsal segment rounded and unarmed; the third ventral segment armed with two tubercles; the seventh ventral segment posteriorly produced ventrad and pointed.

♀. Differs from the male in the following particulars: clypeus with its anterior margin broadly rounded, indistinctly separated from the front, antennae much shorter, weakly incrassate from the third segment to the apex, the apical segment as broad as long, no longer than the preceding, the third segment more than twice as long as the pedicel, longer than segments 4 and 5; tooth of the claws larger; second ventral segment unarmed and last ventral apically simple and rounded.

Generic description drawn from *capicola* Brauns. I have not seen the genotype.

Nigripennis Sauss. (*det.* Brauns) agrees in all respects except that parapsidal furrows are distinct throughout and 2 tubercles are on third instead of second segment.

Type.—Ceramius cercériformis Saussure, genus monobasic.

Habitat.—South Africa.

Species of CERAMIOIDES

cercériformis Saussure, ♂. Cape Colony.

capicola Brauns, ♂, ♀. South Africa.

1902. *Ceramius capicola* Brauns. Zeitsch. f. systematische Hymenopterologie u. Dipterologie, vol. 2, p. 278; vol. 3, p. 68. (On p. 280, lines 14–48 apply to *fumipennis* instead of to *capicola*. In line 17, p. 279, "dorsale" should read "ventrale.")

fumipennis Brauns, ♂, ♀. Cape Colony.

1902. *Ceramius fumipennis* Brauns, ♂, ♀. Zeitsch. f. systematische Hymenopterologie u. Dipterologie, vol. 2, p. 275; vol. 3, p. 68. (On p. 280, lines 15–48 apply to this species.)

schulthessi Brauns, ♂, ♀. Cape Colony.

1902. *Ceramius schulthessi* Brauns, ♀. Zeitsch. f. systemat. Hymenopterologie u. Dipterologie, vol. 2, p. 182.

1913. *Ceramius schulthessi* Brauns, ♂, ♀. Entomologische Mitteilungen, vol. 2, p. 196, pl. 2, fig. 6.

nigripennis Saussure, ♂, ♀. Cape Colony.

1913. *Ceramius nigripennis* Brauns, ♂, ♀. Entomologische Mitteilungen, vol. 2, p. 201, pl. 2, fig. 3. (First description of the male.)

Genus **Jugurtia** Saussure

1894. *Jugurthia* Dalla Torre. Catalogus Hymenopterorum, vol. 9, p. 5.

♀. Shape and general appearance of female of *Pseudomasaris*, eyes very widely separated above, deeply incised, the incision broadly rounded; clypeus scarcely convex, its apical border trilobed; labrum semicircular; mandibles acute, two teeth on the inner margin; ligula retractile, labial palpi 4-segmented, the fourth segment, however, a minute tubercle, the third about equal in length to the second, and bearing three stout curved spines. Antennae as in *Pseudomasaris*.

Humeri rounded dorsally, margined laterally; parapsidal furrows absent; mesonotum flattened but not depressed before the slightly elevated scutellum, tegula elongate, pointed, covering the base of the scutellum, posteriorly punctate, its outer margin entire; apical part of scutellum with a weak depression, the apex weakly bifid; scutellum covering and concealing the rounded postscutellum; propodeum posteriorly flat, its lateral angles weak, neither dentate nor mucronate.

The medio-cubital cross-vein attached opposite to $M_4 + Cu_1$. Middle tibia with two apical spurs beneath, a short one above, posterior tibia with its larger apical spur bifid.

Abdomen as in *Pseudomasaris,* the second ventral segment with a transverse ridge, the last segment broadly rounded at apex.

Habitat.—Asia, Southern Europe, Africa.

Species of JUGURTIA

chlorotica Morawitz, ♀. Transcaspia.

escalerae Meade-Waldo, ♀. Persia.

1910. *Jugurtia escalerae* Meade-Waldo, ♀. Ann. Mag. Nat. Hist., (8), vol. 5, p. 33.

[*neotropica* Moesarya. See *Trimeria neotropica.*]

numida Saussure, ♂. Algeria.

oraniensis Saussure, ♂, ♀. Spain, Algeria.

simpsoni Meade-Waldo, ♀. Gambia.

1911. *Jugurtia simpsoni* Meade-Waldo, ♀. Ann. Mag. Nat. Hist., (8), vol. 8, p. 448.

Table to the Species of JUGURTIA

Meade-Waldo: Ann. Mag. Nat. Hist., (8), vol. 8 (1911), p. 449 (*chlorotica* omitted).

Genus **Masariella** Brauns

Figures 5, 40, 41, 106

Masaris auct. pars.

1905. *Masariella* Brauns. Ann. Hist. Nat. Musei Nat. Hungarici, vol. 3, p. 223.

♂. Head transverse rounded, the posterior margin of the vertex somewhat concave; temples moderately broad, margined posteriorly; ocelli distant from the eyes, these very deeply emarginate, the emargination broadly rounded at apex; clypeus like that of *Pseudomasaris* gibbous, or merely convex, the anterior margin deeply and broadly concave; the labrum prominent, short, rounded at apex; mandibles acute, with one or two teeth within; ligula elongate, retractile, like that of *Masaris;* labial palpi, 4-segmented, the apical segment, minute; maxillary palpi said by Brauns to be 2-segmented. Antennae of the genotype consisting of 12 segments, gradually enlarged into a long oval club from the sixth segment to the apex, flattened but not concave beneath, the club terminating in a slight hook and not distinctly demarcated from the rest of the flagellum, the divisions between all segments distinct, except that the one between the last two is largely obliterated, the scape a little longer than the third segment, more than twice the length of the pedicel; the antennae of *saussurei* are different, the club short, broadly ovate, convex, commencing with the ninth segment.

The rather long neck, and the shape of the head and prothorax are suggestive of *Xiphydria;* the humeri entirely rounded, parapsidal furrows absent; scutellum in the genotype with a median furrow and ending in two tubercles, in *saussurei,* however, simply longitudinally concave; tegula elongate, bluntly rounded, not pointed posteriorly, covering the base of the scutellum, its outer margin entire, coarsely punctured; propodeum concave posteriorly, its side rounded, not carinate, but superiorly mucronate or dentate.

Medio-cubital cross-vein opposite $M_4 + Cu_1$; anterior trochanter unarmed; the tarsal spur arcuate, simple; the tarsus not much shortened and flattened; femora and tibiae with simple surfaces; middle tibia in the genotype with one large apical spur beneath and an additional short stout spine at apex on the upper side; in *saussurei,* there are two stout spurs beneath and one above; the posterior tibial spur, bifid as in *Pseudomasaris;* claws with a small tooth beneath near the base.

Abdomen cylindrical, the last dorsal segment unarmed, the apical margin broadly emarginate; ventral segments unarmed, the seventh of the genotype with a deep depressed pocket at base extending beneath the sixth segment, its apex except in *saussurei* broadly, not deeply rectangularly emarginate, the apical border in the middle of the emargination produced into two teeth with a deep rounded notch between.

Genitalia not examined.

♀. Differs from the male in the following particulars: clypeus convex but not gibbous; antennae much shorter, the segments of the flagellum short, forming a compact oval club, not unlike that found in females of *Pseudomasaris;* spur of anterior tibia shorter and broader; anterior tarsus shorter and flattened; abdominal segments as in female *Pseudomasaris,* the apical segments unarmed and broadly rounded at apex. I have not dissected the mouth parts, but the labial palpi have three segments, the third equal to the second, and bearing one or more stout curved spines near the apex, and there may be a fourth segment represented by a minute tubercle; the maxillary palpi I cannot make out.

Type.—Masaris alfkeni (Du Buysson), genus monobasic.

Habitat.—South Africa.

Key to the Species of MASARIELLA

Males

Club of antenna elongate, oval, not sharply differentiated from rest of flagellum, slightly hooked at tip and flattened beneath; seventh ventral segment with a conspicuous deep basal pocket, extending beneath the sixth, its apical margin broadly rectangularly emarginate, in the middle with two teeth separated by a deep and rounded median notch ..... **alfkeni** (Du Buysson).

Club of antenna very short, broadly ovate, convex beneath, shaped as in *Pseudomasaris texana,* the tip bluntly rounded, not hooked; seventh ventral segment slightly produced and truncate at apex, considerably obscured by numerous long silky hairs at its base with a weakly marked shallow pocket extending beneath the sixth segment ..... **saussurei** Brauns.

Females

Propodeum with posterolateral angles weakly angled above but not dentate; scutellum with a discal depression, not ending in two tubercles ..... **saussurei** Brauns.

Propodeum with its posterolateral angles dentate above; scutellum with a longitudinal median fossa and ending in two tubercles..... **alfkeni** (Du Buysson).

M. saussurei undoubtedly is more closely related to *alfkeni* than it is to the genotype of *Masaris,* in which genus it has heretofore stood, as the following considerations will show. In *Masaris* the ventral segments two and three are both armed with strong processes, in *alfkeni* is probably more like it than that of *saussurei;* the ocelli of the ment is elongate, tapered, and ends in two prominent tubercles or teeth, while in both *alfkeni* and *saussurei* it is short and rounded, the apical margin broadly emarginate; in both *alfkeni* and *saussurei* the larger spur of the hind tibia is bifid, but not so in *Masaris.* Neither the antenna of the male of *alfkeni* or *saussurei* is like that of *Masaris,* but *alfkeni* is probably more like it than that of *saussurei,* the ocelli of the male of *Masaris* are close to the eyes, those of both *saussurei* and *alfkeni* much more distant, this character being due to the much closer approach of the eyes to each other on the vertex in *Masaris;* the postscutellum of *Masaris* is not covered by the scutellum, and is bifid, while in both *saussurei* and *alfkeni* it is entirely covered by the scutellum and rounded, and finally, the subalate lateral angles of the propodeum are of a very different type from that which obtains in both *alfkeni* and *saussurei.*

It is probable that the other South African species now placed in *Masaris* will go in *Masariella* also, but as I have not seen specimens I cannot say. It is further probable that after the species have been thus studied it may become desirable to erect a separate subgenus for *saussurei* and probably others on the basis of the difference in the antennae and seventh ventral segment of the male.

Species

alfkeni (Buysson) Brauns, ♂, ♀. South Africa.

1904. *Masaris alfkeni* Buysson, ♀. Bulletin de la Société Entomologique de France, p. 144.

1905. *Masariella alfkeni* Brauns, ♂. ♀. Annales Historico-Naturales Musei Nationalis Hungarici, vol. 3, p. 223.

saussurei Brauns, ♂, ♀. Cape Colony.

1905. *Masaris saussurei* Brauns, ♂, ♀. Annales Historico-Naturales Musei Nationalis Hungarici, vol. 3, p. 219.

Genus **Quartinia** Gribodo

1904. *Quartinia* Cameron. Zeitschrift für systematische Hymenopterologie und Dipterologie, vol. 4, p. 89.

♂. Head broad, transverse, the eyes very distant from each other and from the ocelli; somewhat, as in the females of *Pseudomasaris,* deeply incised, the incision broadly rounded, clypeus convex; its apex broadly emarginate; mandibles acute, a tooth on the inner margin near the apex. Antennae shorter than the distance between the eyes on the top of the head, resembling those of Pseudomasaris females; the scape is scarcely longer than broad, the pedicel very large, globose, nearly as large as the scape, the third and following segments minute, the eighth and twelfth united into an oval club, convex on all surfaces.

Humeri rounded, parapsidal furrows wanting, mesonotum flattened but not depressed in front of the slightly raised scutellum; tegula very large, considerably larger than the scutellum, very broadly rounded rather than pointed posteriorly, covering the base of the scutellum, with a few coarse punctures on the posterior part, this convex, rounded at apex where it covers the rounded postscutellum; propodeum posteriorly deeply concave, the margins thereof forming a sharp ridge separating the posterior from the lateral surface, but not carinate and without spine or tooth.

Forewings completely plaited longitudinally as in *Celonites* or *Vespa;* the medio-cubital cross-vein attached opposite to $M_4 + Cu_1$; in *variegata* veins, M_2 and m appear as a mere trace, but not in the genotype, a completely enclosed and very large triangular appendiculate cell present. Anterior trochanter unarmed; middle tibia with two weak apical spurs. I cannot make out the posterior tibial spur of *variegata,* but in *deleta* ♀ it appears to be slender and acute; claws small, apparently with a minute tooth beneath.

Abdomen shaped as in *Vespa,* the last dorsal segment short and rounded, its apex margined and deeply bifid; apical margin of last ventral segment sinuate with a broad median tooth.

♀. Except in the broadly rounded last abdominal segment the female does not differ from the male.

The generic description is drawn chiefly from *Q. variegata* Brauns, but the ♀ of the genotype was compared with it. It is not clear, however, that in the latter the wings are longitudinally plaited, and the extent of the wing margin caudad of cell M_3 is much less than in *variegata.*

Type.—Quartinia dilecta Gribodo, genus monobasic.

Habitat.—Africa, India.

Species of QUARTINIA

capensis Kohl. Algo Bay.

1898. *Quartinia capensis* Kohl. Termeszetradji Füzetek, vol. 21, p. 365.

dilecta Gribodo, ♂, ♀. Tunis.

indica Cameron. Deesa.

1904. *Quartinia indica* Cameron. Zeitschrift für systematische Hymenopterologie und Dipterologie, vol. 4, p. 89.

major Kohl. Oran.

1898. *Quartinia major* Kohl. Termeszetradji Füzetek, vol. 21, p. 363.

paradoxa Brauns, ♂. Cape Colony.

1905. *Quartinia paradoxa* Brauns. Annales Historico-Naturales Musei Nationalis Hungarici, vol. 3, p. 324.

parvula Dusmet, ♂. Spain.

1908. *Quartinia parvula* Dusmet. Mem. Pri. Congr. Nat. Espan., 1908, p. 183.

thebaica Buysson. Egypt.

1902. *Quartinia thebaica* Buysson Bulletin de la Société Entomologique de France, 1902, p. 141.

Genus **Celonites** Latreille

Figures 7, 22, 34, 35, 52, 87–90, 104

1906. *Coelonites* Du Buysson. Revue entomologique, vol. 25, p. 103.

♂. Head transverse, posterior surface flat; occiput margined; temples wanting; eyes deeply emarginate, the emargination broad and rounded, distant from each other by three-quarters the length of the scape; ocelli in a very broad triangle, situated well up on the vertex, the posterior much closer to the eyes than to each other; front convex, without tubercles; clypeus strongly convex, shield-shaped, emarginate anteriorly; mandibles acute, with two small preapical teeth on the inner margin; ligula very long, slender and retractile; the labial palpus consisting of a single segment, the apical portion of which is partially marked off as a short incomplete second segment; maxillary palpus consisting of two short, slender segments. Antenna a little shorter than the thorax, strongly clavate; the scape and pedicel of nearly equal length, globose, the third segment cylindrical, a little longer than the pedicel, nearly as long as segments 4 to 5, these as broad as long, 6 and 7 broader than long, segments 8 to 12 fused into a solid, large, oval club, convex above and slightly flattened below, the divisions between the segments distinct beneath; the ninth and tenth segments in a depression beneath bear the cupuliform organs described by Saussure.

Humeri angulate; parapsidal furrows wanting; tegula long, covering the base of the scutellum, pointed, the outer margin weakly sinuate; scutellum rather flat; propodeum raised on each side near its base, the sides horizontally strongly alate.

Wings longitudinally plaited as in *Vespa;* cells R_4 and R_5 of the forewing united; m-cu arising from Cu_1. Anterior trochanter simple, the front tibia with a ridge beneath, but otherwise the femora and tibiae are without irregular or carinate surfaces; anterior tibial spur of a peculiar shape, stalked at base, the apical portion triangular, acute; middle tibia with two apical spurs; larger apical spur of posterior tibia bifid at tip; all claws with a minute tooth well toward the base of each.

Abdomen entirely sessile, fitting close against the alate angles of the propodeum, convex above, tapered toward apex, concave beneath, the sides strongly margined; the posterolateral angles of segments 1 to 6 produced into a flattened rounded tooth, giving the margins a serrate aspect; last dorsal segment with its margin notched, resulting in 4 teeth; last ventral segment with its apical margin shallowly concave.

Genitalia of the peculiar type shown in figure 52.

♀ differs from the male as follows: club of the antenna more slender, convex beneath and without the cupuliform organs; mandible blunt, the inner margin near the apex indistinctly serrulate; labial palpus of three segments, the first stout, curved, with a ventral row of four apical setae, the second short, with two setae of which one is very prominent, the last segment about one and one-half times as long as the second, curved, slightly widened toward the apex, obtuse, with a row of setae extending obliquely across the apex, of which four or five are stout. Wings strongly plaited as in the male; anterior tibial spur curved, slender throughout, or very slightly widened toward the tip; hind tibial spur as in the male; last dorsal segment with its margin merely weakly sinuate; the last ventral segment large, obtusely pointed at apex, with a median longitudinal ridge.

Type.—Masaris apiformis Fabricius; genus monobasic.

Habitat.—Mediterranean subregion, Africa.

The difference between the sexes in the labial palpi closely parallels that found in *Pseudomasaris,* the condition in the corresponding sexes being very similar in each genus. The labial palpi are described by Saussure as of four segments, but this is true of neither sex. That author did not observe the sexual disparity in the palpi, nor has it been previously recorded by any author, so far as I am aware. In respect to the bifid spur of the posterior tibia this genus is also similar to *Pseudomasaris,* but of course in many other characters it is very different.

The generic description is drawn from a study of the type species alone, and it is of course possible that other species may modify it.

List of Species of CELONITES

abbreviatus (Villers) Saussure, ♂, ♀. Mediterranean subregion.

1793. *Masaris apiformis* Fabricius.

var. *hungaricus* Moesarya, ♂, ♀. Hungary.

andrei Brauns, ♂, ♀. Cape Colony.

1905. *Celonites andrei* Brauns, ♀. Annales Historico-Naturales Musei Nationalis Hungarici, vol. 3, p. 228.

1913. *Celonites andrei* Brauns, ♂. Entomologische Mitteilungen, vol. 2, p. 206. Description of male and of nest.

capensis Brauns, ♂, ♀. Cape Colony.

1905. *Celonites capensis* Brauns, ♀. Annales Historico-Naturales Musei Nationalis Hungarici, vol. 3, p. 231.

1913. *Celonites capensis* Brauns, ♂. Entomologische Mitteilungen, vol. 2, p. 205.

clypeatus Brauns, ♀. Cape Colony.

1913. *Celonites clypeatus* Brauns, ♀. Entomologische Mitteilungen, vol. 2, p. 206.

crenulatus Morawitz, ♀. Transcaspia.

cyprius Saussure, ♂. Cyprus.

fischeri Spinola, ♂, ♀. France, Algeria.

1906. *Celonites fischeri* Du Buysson. Revue Entomologique, Caen, vol. 25, p. 103.

jousseaumei Du Buysson. Oboek.

1906. *Coelonites jousseaumei* Du Buysson. Revue Entomologique, Caen, vol. 25, p. 104.

mongolicus Morawitz, ♂, ♀. Mongolia.

montanus Moesarya.

1906. *Celonites montanus* Moesarya. Annals and Magazine of Natural History, vol. 4, p. 198.

osseus Morawitz, ♀. Transcaspia.

promontorii Brauns, ♂, ♀. Cape Colony.

1905. *Celonites promontorii* Brauns, ♀. Annales Historico Naturales Musei Nationalis Hungarici, vol. 3, p. 232.

1913. *Celonites promontorii*, ♂. Entomologische Mitteilungen, vol. 2, p. 205.

purcelli Brauns, ♂, ♀. Cape Colony.

1905. *Celonites purcelli* Brauns. Annales Historico-Naturales Musei Nationalis Hungarici, vol. 3, p. 226.

1913. *Celonites purcelli* Brauns. Entomologische Mitteilungen, vol. 2, p. 205.

rothschildi Du Buysson. East Africa.

1906. *Coelonites rothschildi* Du Buysson. Revue Entomologique, Caen, vol. 25, p. 105.

savignyi Saussure, ♂, ♀. Egypt.

wheeleri Brauns, ♂, ♀. Cape Colony.

1905. *Celonites wheeleri* Brauns. Annales Historico-Naturales Musei Nationalis Hungarici, vol. 3, p. 230.

var. *immaculatus* Brauns.

1905. *Celonites wheeleri* var. *immaculatus* Brauns. *Loc. cit*, p. 230.

1913. *Celonites wheeleri* var. *immaculatus* Brauns. Entomologische Mitteilungen, vol. 2, p. 205.

Tables to Species

South Africa.

Brauns, Hans. Entomologische Mitteilungen, 1913, vol. 2, p. 207.

Mediterranean subregion.

André, Edmond. Species des hyménoptères d'Europe et d'Algérie . . ., vol. 2, pp. 826–829. Tabulates *abbreviatus, fischeri,* and *cyprius.*

Genus **Masaris** Fabricius

Figures 18, 28, 29, 30, 49–51, 83, 95, 107.

♂. Head transverse; the occiput immargined; temples narrow; eyes large, distant from one another above by little more than the distance between the hind ocelli, with a triangular emargination, the apex of which is obtuse; ocelli in an equilateral triangle, crowded forward, distant from the occiput, the hind pair almost touching the eyes; front comparatively flat, with neither tubercles nor a ridge; clypeus moderately convex, its anterior edge deeply emarginate; mandible acute, the inner edge with two preapical teeth, the more apical one fair sized; labial palpus with four segments, the apical segment very short; maxillary palpus reduced to a single segment represented by a mere tubercle. Antenna longer than head and thorax united, gradually widened into an oval club, which is convex on all sides; the scape subglobular; the pedicel short, segments 3 to 5 elongate, cylindrical, 6 and 7 gradually evenly widened, longer than broad; segments 8 to 12 fused, but the divisions distinguishable.

Humeri marked by a ridge; parapsidal furrows absent; tegula elongate, reaching over the base of the scutellum, the apex obtuse, the outer margin weakly and broadly emarginate mesally; scutellum convex; postscutellum prominent, bifid at apex; propodeal angles horizontally subulate, forming acute angles.

Forewing not plaited; lacking R_1; m-cu arising from M_4. Anterior trochanter unarmed; all femora and tibiae with regular surfaces, some of them slightly flattened and with a weak ridge beneath, but devoid of tubercles and carinae; anterior tibial spur slender, slightly curved, the tip acuminate and bent outward; middle tibia with two stout spurs; longer spur of the posterior tibia pectinate at apex (see fig. 95); tarsal claws each with a minute tooth on the middle of the inner margin.

Abdomen sessile, slender, broadest at base, the first segment from a dorsal view somewhat concave anteriorly, the second to fifth dorsal segments somewhat contracted at base, the last bidentate and deeply notched at apex; second and third ventral segments each with a process, that of the second acute, of the third larger and transverse; last ventral segment with the apical margin weakly concave.

Squama simple, obtuse; sagitta thick, short, roughly trigonal; uncus slender, acute, decurved. The genitalia are similar in type to *Pseudomasaris*.

I have not seen a female. The description is drawn from a male of the type species, subspecies *aegyptiacus*.

Type.—*Masaris vespiformis* Fabricius, by designation of Latreille, 1810.

Habitat.—Africa.

Species of MASARIS

discrepans Brauns, ♂, ♀. Cape Colony.

1913. *Masaris discrepans*, Brauns, ♂, ♀. Entomologische Mitteilungen, vol. 2, p. 203, pl. 2, fig. 9a.

[*saussurei* Brauns, ♂, ♀. Cape Colony. See *Masariella*.]

spinolae Saussure, ♀. Cape Colony.

vespiformis Fabricius, ♂, ♀. Egypt, Algeria.

1911. *Masaris vespiformis* Meade-Waldo. Annals and Magazine of Natural History, (8), vol 8, p. 445, illus.

subspecies *aegyptiacus* Meade-Waldo, ♂. Egypt.

1911. *Masaris vespiformis* subspecies *aegyptiacus* Meade-Waldo, ♂. Annals and Magazine of Natural History, (8), vol. 8, p. 447, illus.

Genus **Pseudomasaris** Ashmead

Figures 6, 10, 19–21, 31–33, 96, 108.

1902. *Pseudomasaris* Ashmead. Canadian Entomologist, vol. 34, p. 221.

♂. Eyes deeply emarginate; mandibles acute, with two minute denticulations on the inner margin; clypeus convex, the apical margin broadly emarginate; glossae very elongate, retractile, about 7 times as long as the paraglossae; labial palpus usually 2-segmented, rarely 1- or 3-segmented, in which case the first segment is much longer than the following, and the third if present is stout and shorter than the second, the second segment may be indistinctly separated from the first; maxillary palpus reduced to a single segment, usually a mere tubercle, sometimes exceedingly minute; a distinct lacinia present, with a ciliate inner margin, also a subgalea and sometimes what probably represent two lobes of the galea, sometimes only one. Segments 8 to 12 of the antennae closely fused into a club, which may be concave or convex beneath, and is of varying shape; scape short, nearly globular, pedicel short, segments 3 to 5 linear, the sixth and seventh sometimes widened, occasionally much so.

Tegula elongate, the outer margin notched; parapsidal furrows absent.

Anterior trochanter unarmed; tarsal claws simple; middle tibia with one apical spur; posterior tibial spur bifid. Forewing with cells R_1 and R_5 coalesced (2 submarginal cells); m-cu arising from M_4.

Abdomen sessile, the second, third, and fourth dorsal segments constricted at base, the last dorsal decurved, its apex, seen from the side,

truncate, the truncate portion from a caudal view nearly rectangular, margined above and below by a pair of strong, tooth-like processes, the inferior pair closer together than the superior, sometimes an additional pair of tubercles cephalad of the upper pair; second ventral with a low tubercle, the third with a strong, variously shaped, process; seventh ventral segment deeply divided by a usually square broad notch. Squama and ramus fused, the former lamelliform, rarely thickened, curved, often densely ciliate beneath; sagitta and volsella small, closely applied to the ramus; uncus usually long and slender, decurved at apex, with a pair of barbs at base, sometimes thick and without barbs at base.

♀. Eyes deeply emarginate, the emargination wide and rounded at apex, eyes at least 3 times as far apart above as the distance between the hind ocelli; mandibles bluntly rounded or truncate at apex, with 2 denticulations on the inner margin; labial palpi 3-segmented, the first flattened, the second short, bent at right angles to the second, the third much longer, falcate, very slender, tipped with 2 stout spines. Antennae shorter than the width of the head; scape more than twice as long as pedicel; third segment linear, as long as 3 or 4 following segments united, segments 4 to 7 increasingly thickened, the seventh broader than long, segments 8 to 12 fused into an oval club, convex above and below, the divisions distinguishable, but that between the eleventh and twelfth sometimes very indistinctly so.

Abdomen unarmed. The segments not constricted at base, the seventh tergite and sternite with rounded apical margins. In other respects similar to the male.

Type.—Masaris occidentalis Ashmead, by original designation.

Habitat.—Southwestern United States.

Key to the Subgenera of PSEUDOMASARIS

A. Posterior metatarsus of the male arcuate, produced at apex on the inner side into a lobe bearing a prominent crest of ciliae; segments 6 and 7 of the antennae of the male much longer than wide, the club shaped like the inverted bowl of a spoon, concave beneath; anterior tarsus of the male ciliate; anterior tibia and middle femur and tibia of the male contorted, of the female merely flattened beneath, the tibiae constricted at base; posterolateral angles of the propodeum alate; last dorsal segment of the male with 6 tubercles; female with a transverse carina between the antennae; squama very thick, the apex rugose ..... **Toryna**, n. subg.

AA. Posterior metatarsus straight or nearly so, without an apical lobe; club of the male convex beneath, or if concave it is short ovate, not spoonlike, the seventh segment as broad as long, or the sixth and seventh segments form part of the club, the inner margin of which is serrate, and the seventh segment much broader than long; female without a carina between the antennae; last dorsal segment of the male with 4 tubercles; squama laminate or slightly thickened, the apex even.

B. Eyes of the male reaching the posterior margin of the head, touching each other on the vertex, or separated by a distance less than that between the posterior ocelli; these touching the eyes, 3 times as far

from an imaginary line connecting the posterior borders of the eyes as from each other; seventh segment of antenna of male slightly widened at apex, much longer than broad, the club solid, ovate, shorter than segments 6 plus 7, convex above and below, slightly flattened at base beneath; middle femur and tibia with even surface, rounded or flattened but not concave beneath and without irregularities ..... **Holopticus,** n. subg.

BB. Eyes of the male not reaching the posterior margin of the head, distant from each other by at least twice the distance between the posterior ocelli; these not touching the eyes, distant from an imaginary line connecting the posterior borders of the eyes by not more than twice their distance from each other; antennae of the males of different forms; either the middle femur or tibia or both of the male irregularly contorted, grooved or armed beneath, sometimes also that of the female, but less strongly than in the male.

C. Antennal club of the male solid, ovate, thick, sometimes hollowed beneath, as long as or slightly longer than segments 6 plus 7, these not forming part of the club, the seventh segment at least as long as broad, usually longer; inner surface of squama of male not fimbriate ..... **Pseudomasaris** Ashmead.

CC. Sixth and seventh segments of the antenna of the male forming part of the club, the remaining segments indistinguishably fused, recurved like a half-closed hand, concave beneath, this part of the club scarcely longer than the sixth segment, posterior margin of the club strongly serrate, by reason of the irregularly projecting margin of the sixth and seventh segments, the seventh segment more than 3 times as broad as long, less than one-third the length of the sixth; inner surface of the squama of the male fimbriate ..... **Cotyledon,** n. subg.

A Key to the Species of the Genus PSEUDOMASARIS

Males

1. Last dorsal segment with 6 tubercles; posterior metatarsus curved and with a ciliate lobe at apex within; antenna resembling an inverted spoon ..... **(Toryna) vespoides** (Cresson).

   Last dorsal segment with 4 tubercles; posterior metatarsus without a lobe ..... (2)

2. Sixth and seventh segments of the antenna forming part of the club, the seventh flattened, over 3 times as broad as long, their irregular edges making the posterior margin of the club strongly serrate; front with a prominent tubercle between the emarginations of the eyes ..... **(Cotyledon) edwardsii** (Cresson).

   Sixth and seventh segments of the antenna not forming part of the club, or if so the seventh is cylindrical and but little widened, the seventh segment as long as broad, or longer, club short ovate and thick, rarely hollowed beneath, the posterior margin not serrate; front flat, or with a weak median prominence ..... (3)

3. Eyes reaching the posterior margin of the head, closer together than or about as close together as the distance between the posterior ocelli, these touching the eyes or very nearly so ..... **(Holopticus).** (4)
   Eyes not reaching the posterior margin of the head, at least twice as far apart as the distance between the hind ocelli; these not touching the eyes ..... **(Pseudomasaris).** (8)
4. Eyes separated by from three-quarters to one and one-half times the diameter of a posterior ocellus; fourth segment of antenna linear; process of third ventral segment with a broad longitudinal fossa on its summit, without two teeth in front, and without a posterior tooth ..... (6)
   Eyes separated by twice or three times the diameter of a posterior ocellus ..... (5)
5. Process of third ventral segment with a narrow longitudinal groove on its summit, two teeth in front, and a large sharp tooth pointing caudad behind; eyes separated by twice the diameter of a posterior ocellus ..... **bariscipus,** n. sp.
   Process of third ventral segment with a broad fossa on its summit much widened anteriorly, the process without teeth in front and obtuse behind; eyes separated by three times the diameter of a posterior ocellus ..... **phaceliae** Rohwer.
6. Eyes separated by less than the diameter of a hind ocellus ..... (7)
   Eyes separated by about one and one-half times the diameter of a hind ocellus; front femur black and yellow ..... **rohweri,** n. sp.
7. Anterior femur brown with a white area beneath at apex; sides of propodeum weakly angled, not alate nor mucronate ..... **albifrons** Rohwer.
   Anterior femur usually entirely red or reddish yellow without an apical white spot; side of propodeum subulate and mucronate ..... **texanus** (Cresson).
8. Sixth and seventh antennal segments not flattened beneath, the sixth cylindrical or slightly widened at apex, the club convex beneath, middle femur and tibia or the tibia only strongly contorted and concave beneath ..... (9)
   Sixth and seventh antennal segments flattened beneath, strongly widened, the club concave beneath; middle femur concave beneath, with a tubercle near the apex, the tibia slightly irregularly concave beneath ..... **marginalis** (Cresson).
9. Middle femur and tibia both strongly contorted and concaved beneath; seventh segment of the antenna three-quarters as wide as long ..... (10)
   Middle femur with the inferior surface evenly rounded, the tibia on its outer lower edge strongly produced and angled on the basal third; seventh segment of the antenna one-half as wide as long ..... **occidentalis** (Cresson).
10. Antenna evenly and not strongly clavate from the sixth segment to the apex, forming a slender oval club; middle tibiae weakly ridged beneath ..... **coquilletti** Rohwer.
    Antenna with the club broadly ovate, strongly differentiated from the rest of the flagellum; middle tibia strongly ridged beneath ..... **zonalis** (Cresson.)

Females

1. A sharp transverse carina between the antennae; clypeus coarsely transversely rugose ..... **(Toryna) vespoides** (Cresson).
   No carina between the antennae; clypeus not rugose, but chagreened or punctate ..... (2)
2. Angles of propodeum mucronate or dentate ..... (3)
   Angles of propodeum rounded, not dentate ..... **(Pseudomasaris) marginalis** (Cresson).
3. Middle tibia, seen from above, inflated beyond the middle; middle femur with its inner posterior margin carinate and more or less sinuate; color black and bright yellow..... **(Cotyledon) edwardsii** (Cresson).
   Middle tibia, seen from above, not inflated ..... (4)
4. Middle femur scarcely flattened and not ridged beneath; color of the body partly tawny, ferruginous or rufous, or at least the legs beyond the coxae all tawny except sometimes for a yellow spot on the femora..(5)
   Middle femur flattened beneath, its anterior lower border marked by a ridge; color black and saffron or lemon yellow, without rufous or tawny markings ..... (10)
5. Clypeus very coarsely and densely punctate, almost rugose; tawny, inverted V-shaped spot on front, mesonotum except next to the tegulae, mesoventer, sometimes part of pleura and lower part of propodeum, mesal spot on dorsal segments 1, 2, and 3, and a mesally dilated basal border on dorsal segments 4 and 5, and a narrow basal border on ventral segments 4, 5, and 6, black..... **(Pseudomasaris) occidentalis** (Cresson).
   Clypeus weakly and shallowly punctate, sometimes punctulate with scattered coarser punctures; black, with yellow and usually with rufous marking ..... **(Holopticus)** (6)
6. Middle of mesonotum just in front of scutellum very densely and finely granular-punctate; second dorsal segment closely, rather finely and evenly punctate, matte ..... (7)
   Middle of mesonotum in front of scutellum coarsely, confluently, almost rugosely punctate, this area of the mesonotum strongly depressed; second ventral segment with separated coarser punctures, the abdomen and pronotum more or less polished and shining; color black, saffron yellow and red, with a strong preponderance of yellow on the abdomen ..... **phaceliae** Rohwer
7. Mesonotum just in front of scutellum with a strongly depressed area, not reaching the lateral groove of either side, this area finely granular, while the raised area at the sides and anteriorly is more coarsely and sparsely but still densely punctate; front always with a triangular white area, legs beyond coxae entirely reddish ..... (8)
   Mesonotum in front of scutellum flat, but without a median depressed area, the sides and anteriorly finely and densely punctate, but not granular as in the middle just before the scutellum; front usually without a white spot ..... (9)
8. Thorax and abdomen with a large amount of red ..... **texanus texanus** (Cresson).

Thorax and abdomen without red marking ..... **texanus neomexicanus** Rohwer.

9. Front without a median white triangle; knees white; three basal abdominal segments with their ground color dorsally mostly red ..... **basirufus** Rohwer.

Front with a median white triangle; legs beyond coxae entirely rufous; two basal segments of abdomen with ground color partly red ..... **maculifrons** (Fox).

10. Seen from behind, the middle tibia strongly contracted near its base; cephalic margin of cell R_{4+5} less than one-half the distance between M_{3+4} and M_2 on its caudal border; humeral ridge well marked; abdomen elongate; propodeum except the angles, femora except their apices, postscutellum and most of clypeus black ..... **(Pseudomasaris) zonalis** (Cresson).

Middle tibia gradually widened from base to apex; cephalic margin of cell R_{4+5} more than one-half the distance between M_{3+4} and M_2 on its caudal margin; humeral ridge almost obsolete; abdomen short, ovate; propodeum, except two spots behind, femora, except basal half to three-quarters of posterior surfaces, postscutellum at apex, and most of clypeus, saffron yellow ..... **(Pseudomasaris) coquilletti** Rohwer.

Toryna, new subgenus

♂. Eyes deeply emarginate, the emargination obtuse, the eyes more than twice as far apart above as the distance between the hind ocelli; labial palpus 2-segmented, the first more than twice as long as the second; maxillary palpus very short and conical. Antenna a little longer than the head and thorax united, the scape short, globose, the pedicel less than one-half its length, segm. 3 to 7 distinct, 3 to 6 linear, the seventh widened, about one and one-half times as long as thick at apex, segm. 8 to 12 fused to form an oval club, shaped like the inverted bowl of a spoon, convex above and concave beneath, the divisions between these segments only faintly apparent.

Anterior femur normal, its undersurface convex, the tibia somewhat contorted, obliquely constricted at base, as long as the tarsus, the latter with a lateral fringe of rather long, silky hairs; metatarsus as long as the following segments united, the fourth segment broader than long; middle femur with irregular ridges and fossae beneath, the tibia from a lateral view constricted at base and strongly expanded toward the apex, the expansion beneath with a fossa which fits over the femur; tibia one-fifth longer than the tarsus, fourth segment of the latter much broader than long; posterior tibia as long as the metatarsus; metatarsus one and three-fifth times as long as the remaining segments united, plainly curved, its apex produced on the inner side into a rounded lobe extending well beyond the base of the following segment, and bearing a prominent crest of stout setae; hind tarsal segments 2 to 4 with a prominent inner fringe of setae; the fourth segment about as long as wide; second and third ventral segments both with tubercles;

last dorsal segment, in addition to the four tubereles bordering its truncate apex, has a pair of tubercles on the dorsal surface.

♀. A sharp transverse carina between the antennae; elypeus very convex and rugose; labial palpi 2-segmented, the first more than twice as long as the second, maxillary palpus very short and conical.

Anterior femur flattened beneath, the tibia with a weakly irregular undersurface as long as the tarsus; the latter without a fringe of ciliae; the metatarsus one-half as long again as the remaining segments united; the fourth segment broader than long; middle femur flattened beneath; the tibia slightly flattened beneath, not irregular, but constricted at base, the outer surface bearing scattered short spines, very slightly shorter than the tarsus, bearing 1 apical spine; metatarsus as long as the following segments together, the fourth about as long as broad; posterior tibia about one-third shorter than its tarsus, the apical spur bifid; metatarsus one-half as long again as the remaining segments united, not noticeably curved and without an apical lobe, the fourth segment about as long as broad.

Abdomen unarmed.

Type.—*Masaris vespoides* Cresson.

Pseudomasaris (Toryna) vespoides (Cresson)

Figures 21, 65, 66, 67, 86, 96

1863. *Masaris vespoides* Cresson, ♂, ♀. Proceedings of the Entomological Society of Philadelphia, vol. 2, p. 287, pl. IV.

1904. *Pseudomasaris vespoides* von Dalle Torre. Genera Insectorum, fasc. 19, p. 8

1913. *Masaris vespoides* Davidson. Bulletin Southern California Academy of Sciences, vol. 12, p. 17 (life history).

1913. *Pseudomasaris vespoides robertsoni* Cockerell. Proceedings of the Entomological Society of Washington, vol. 15, p. 107.

♂. Front rugosely punctured, raised below the front ocellus, with a transverse ridge between the antennae, which is polished and impunctate; elypeus very convex, its disc polished and with few large punctures, its sides with close, smaller punctures and somewhat wrinkled.

Humeri prominent, but not angled, without a distinct humeral ridge; mesonotum anteriorly closely punctate, and with a median ridge posteriorly with two lateral ridges between which it is depressed, smooth and polished, with only minute shallow and sparse punctuation; scutellum prominent, polished and practically impunctate.

Basal abdominal segments strongly constricted at base, closely and finely punctate, a median area at base of each except the first two, impunctate, polished; medial punctures finer toward the apex of each segment; second ventral segment with two anterior tubercles and two weak ones behind; third ventral segment with a strong tricuspid prominence.

Color black and pinard yellow, the latter distributed as follows: clypeus, labrum, mandibles except base and apex, inner orbits above emargination, line behind eyes, broad humeral stripe, tegula, small spot in front on tip of pronotum and within on mesonotum in front of scutellum (sometimes wanting), large spot below tegula, two short stripes on mesonotum behind (usually absent), large or small apical spot on scutellum, usually the angles of the propodeum; legs beyond middle of femora, sometimes also base of middle femora behind and spot on front and middle trochanter and coxae behind; subapical band on dorsal segments 1 to 5, varying in width and nature of its lateral incisions, the fifth usually enclosing a black spot on each side, most of sixth and apical half of seventh segments, spot at side of second and third ventral segment, sometimes prominence of third posteriorly, and nearly all of the fourth to sixth ventral segments; antennae yellow grading into deep chrome above, and marked with reddish brown beneath.

Wings stained yellow, the veins yellow (Mars yellow). Length, 17–22 mm.

The punctuation is variable, the posterior part of the mesonotum and the scutellum being sometimes punctate throughout. The color is also somewhat variable.

♀. Clypeus coarsely rugose at base; similar to the male, but yellow less extensive, the clypeus and labrum except two small spots, on each, most of mandibles and scape, hind angles of prothorax, mesonotum except spot next to tegula, scutellum except tip and angles of propodeum except the tooth, more of femora, broader basal parts of abdominal segments, nearly all of last ventral segment black, the last dorsal segment black with a large yellow spot on each side; antennal club fuscous above, Sanford brown beneath. Length, 15–19 mm.

This is our largest and most handsome species. Its biology has been described by Davidson (*loc. cit.*). It builds clay nests.

The subspecies described by Professor Cockerell from California does not appear, on comparison with other specimens from California and elsewhere, to represent more than an individual variation.

Types.—Lectotype, ♂: American Entomological Society, no. 2095. Allotype: American Entomological Society.

South Dakota: Lead City, 1 ♀ [American Entomological Society].

Idaho: Lewiston, 1 ♂, 2 ♀; Craig's Mt., 1 ♂, 1 ♀ [American Entomological Society].

Colorado: Pikes Peak, 1 ♂, 2 ♀ (W. J. Howard), [types, American Entomological Society]; Garden of the Gods, July 13, 1877 [U. S. National Museum]; Florissant, July 21, 1 ♀ on flowers of Pentstemon (T. D. A. Cockerell), [American Museum of Natural History].

New Mexico: Jemez Springs, May 20, 1913, 1 ♀; June 2, 1913, 6400 feet, 1 ♂ (J. Woodgate), [Cornell University].

Utah: Pronotetali, August 21, 1906, 1 ♀ [Cornell University]; Silver Lake, July 14, 1 ♂, 1 ♀ (H. Skinner), [American Entomological Society].

Nevada: [American Entomological Society]; 1 ♂ [American Museum of Natural History].

California: Claremont, 2 ♂, 2 ♀ (C. F. Baker), [Pomona College and Cornell University]; Redlands, 1 ♀ (G. Robertson), [type of subspecies *robertsoni* Cockerell, U. S. National Museum, Cat. no. 15529]; Pasadena, June 12, 1895, 1 ♀ (R. W. Doane), [Cornell University]; Los Angeles [U. S. National Museum]; summit of Sierra Nevada, 1 ♀ [American Museum of Natural History]; Strawberry Valley, El Dorado Co., 7 ♀, August 9, 13, 1912 (E. C. Van Dyke), [Calif. Acad. Sci. and Cornell Univ.]; Fallen Leaf Lake near Lake Tahoe, 1 ♂, July 19, 1915 (L. S. Rosenbaum), [Calif. Acad. Sci.]; Carrville, Trinity Co., 1 ♂, 1 ♀, June 29, 1913 (E. C. Van Dyke), [Calif. Acad. Sci. and Cornell Univ.].

Holopticus, n. subgenus

♂. Eyes deeply emarginate, emargination very narrow or acute, eyes reaching the posterior margin of the head and almost touching above, or separated by less than the distance between the hind ocelli; labial palpi with three distinct segments, or with two, the apical portion of the second contracted but not discrete. Scape short, barrel shaped, segments 3 to 6 cylindrical or with apices nodose, seventh widened at apex, twice as long as wide, 8 to 12 indistinguishably fused in a solid ovate club, convex above and below, not as long as segments 6 to 7.

Angles of the propodeum dentate.—Anterior tarsus with ciliate hind margin; all femora with surface regular and convex throughout; anterior tibia regular; middle tibia somewhat depressed and flattened beneath but not contorted nor with irregularities, two-thirds as long as the tarsus, the metatarsus two-thirds to four-fifths as long as the remaining segments united, the fourth as long as wide; hind tibia three-quarters as long as the tarsus; the metatarsus straight, without an apical lobe, as long as the following segments united; the fourth segment longer than wide.

Second ventral segment with two tubercles unarmed, the third with a large process, of variable shape, but bearing a longitudinal groove on its summit; last dorsal segment with four tubercles, the inferior pair small and close together.

♀. Front without a carina between the antennae, clypeus not rugose.

Legs as in the male, except the middle metatarsus is about equal to the remaining segments united.

Type.—*Masaris texanus* (Cresson).

Pseudomasaris (Holopticus) texanus (Cresson)

Figures 56, 57, 58

1871. *Masaris texanus* Cresson, ♂, ♀. Transactions of the American Entomological Society, vol. 3, p. 348.

1904. *Pseudomasaris texanus* Dalle Torre. enera Insectorum, fasc. 19, p. 8.

♂. Spots on clypeus, spot on each side of pronotum, legs, except coxae, small median spot on mesonotum, spot on pleura, most of border of first dorsal segment, spot on each side of second and third dorsal segment, and the second and third ventral segments chestnut; segments 4 to 7 beneath except at apices, club of antenna beneath at base, spot on clypeus, upper part of front and inner orbits, upper margin of pronotum, spot in middle of mesonotum, 2 small anterior spots and 2 posterior touching the tegulae, apex of scutellum, angles of propodeum, 2 spots in red border of first dorsal segment, sides and spot in middle of second and third dorsal segments and borders of fourth to sixth, and band on the fourth and fifth ventral segments yellow.

Punctuation of front and clypeus fine and close; of mesonotum coarser, but close; the posterior part of disc of mesonotum depressed and closely punctate; scutellum closely punctate, propodeal angles mucronate. Dorsal segments moderately depressed and but scantily punctate at base, the apices finely punctate; second ventral segment without tubercles.

Squama moderately thick, obtuse, densely pubescent on the inner side, and with a small pubescent patch on the outer side at tip; sagitta trigonal with obtuse tip and sharply carinated angles, about half as long as the uncus; this long, slender, strongly but gradually decurved toward the tip, with a carina but not a barb beneath near the base.

♀. Antenna, apex of clypeus, pronotum, legs except coxae, spot on scutellum, stripe on first dorsal segment (with included yellow spot), large spot on each side of second segment, chestnut; spot on clypeus, on face, orbits, narrow upper border of pronotum, tegulae, spot on pleura, on apex of scutellum, angles of propodeum, sides and middle of apex of first dorsal segment, apical margins of remaining dorsal segments and of the ventral segments yellow, the yellow on the abdomen obscure; front except on the white spot and vertex with regular, round, dense but separated punctures, irregular and smaller behind the ocelli; clypeus with minute punctuation in addition to coarser punctures; dorsum punctured like the front, but in the depressed area before the scutellum densely granular punctate; abdomen opaque, densely finely and evenly punctate.

Types.—Holotype: ♂. American Entomological Society, no. 2100. Allotype: American Entomological Society.

Texas: 3 ♂, 2 ♀ (Belfrage), [American Entomolgical Society]; Austin, 1 ♀, May 5, 1901 (C. T. Bruers), [Jos. Bequaert].

Arizona: Phoenix, 1 ♂ [Dr. Jos. Bequaert].

Subspecies **Neomexicanus** Rohwer

1912. *Pseudomasaris zonalis neomexicanus* Rohwer, ♀. Proceedings United States National Museum, vol. 41, p. 452.

♀. Black with the following parts straw yellow: wedge-shaped spot on clypeus, triangular spot on middle of frons, spot filling incision of eyes, posterior orbits narrowly to a point opposite incision of eyes,

large oval spot on sides and narrow posterior border of pronotum, tegulae, lateral posterior spot on mesoscutum above tegulae, superior spot on pleura, apical spot on scutellum, spot on angles of propodeum, broad apical bands on tergites one to five inclusive, incised laterally on tergites three, four, and five, interrupted preapical band on sixth tergite, interrupted apical band on second, complete on third and fourth and four apical spots on fifth sternites; the following parts burnt sienna: mandibles, antennal club beneath and legs below coxae; following parts piceous: flagellum except where mentioned and apical margin of sixth sternite; wings slightly smoky, the costa castaneous, the other veins dark brown; hair of head and thorax blackish.

Front dull, with large separate punctures which are much closer medially; clypeus finely punctulate with a few large punctures dorsally. Humeri rounded; pronotum with separated punctures; mesonotum with large, sometimes confluent punctures which are closer and finer in the flattened posterior part; scutellum with large, distinct punctures laterally and with a rather narrow granular area medianly; sides of the pronotum mucronate, not carinate. Abdominal segments evenly, finely and closely punctate; bases of second and third tergites somewhat contracted. Length, 10 mm.

Type.—U. S. National Museum, no. 14145.

New Mexico: Aztec, May 4, 1899, 1 ♀ at flowers of *Astragalus* [type, U. S. National Museum].

Mr. S. A. Rohwer has very kindly sent me the redescription of the type here published.

Pseudomasaris (Holopticus) albifrons Rohwer

1912. *Pseudomasaris albifrons* Rohwer, ♂. Proceedings United States National Museum, vol. 41, p. 451.

"♂. Length about 12 mm. Very like *texanus* (Cresson), from which it may be separated by the following characters: very few large punctures on the front and these not sharply defined; posterior part of mesoscutum uniformly punctured (in *texanus* the depressed area is more closely punctured); punctuation of abdomen finer; second dorsal segment depressed by fully half of its entire length (in *texanus* it is hardly depressed); third segment hardly depressed (in *texanus* it is depressed by fully one-third); punctures of the apical dorsal segment more widely separated; second cubital cell on the radius longer, being in the type greater than the distance between the recurrent veins (in *texanus* it is much less); markings whitish; clypeus except apical part pale; wings slightly yellowish in stigmal area, otherwise hyaline."

Holotype.—U. S. National Museum, no. 14144.

New Mexico: Las Cruces, 25 March, 1896, on plum (T. D. A. Cockerell), [type, U. S. National Museum].

Utah: 1 ♂ (Palm), [U. S. National Museum].

Pseudomasaris (Holopticus) rohweri, n. sp.

♂. Black, the following parts chestnut to Sanford brown; most of the fifth, sixth, and seventh antennal segments above, scape toward apex, front tibia except spot on outer side at base, front tarsus, hind and middle legs except coxae and trochanters, wing veins, second dorsal segment except for 3 yellow spots, third dorsal segment except for 3 yellow spots and base, 2 spots and median apical border on fourth dorsal segment, second ventral segment, third ventral segment except near base; following parts pale chalcedony yellow; large spot on clypeus above, emargination of eyes, upper part of front and vertex, narrow line behind the eyes, fifth and sixth antennal segments beneath except at extreme apex, antennal club beneath at base, pronotum above except posteriorly, tegulae, large spot on pleura beneath, triangular spot on each side of mesonotum in front, small median spot, spot on each side next to tegulae, apex of scutellum, angles of propodeum, spot at apex of anterior femur and base of tibia, broad subapical band on first dorsal segment, 3 transverse spots on second and third, sinuate subapical bands on fourth, fifth, and sixth dorsal segments and subapical bands on fourth and fifth ventral segments. Wing stained with yellow along costal margin; head and thorax rather noticeably pubescent.

Front prominent, clypeus gibbous, emargination of eyes very narrow, almost acute, front and clypeus shallowly and rather obscurely punctured, labial palpi with 3 segments, the last rather closely fused to the preceding. Scape globular, third segment shorter than the fourth, this not enlarged at apex, short pubescent throughout, fifth and sixth but slightly enlarged at apex, third to seventh segment somewhat compressed, the seventh much widened at apex, about twice as long as wide; club short, ovate, somewhat flattened below at base, about as long as segments 6 and 7.

Mesonotum rather coarsely and closely punctate, the depressed area more closely; the scutellum more finely and closely punctate, also with large scattered punctures, pleura with coarse punctures.

Anterior tarsus ciliate, segments of legs with regular surfaces; middle tibia flattened beneath and from an external view considerably widened medially; middle tibia about two-thirds as long as the tarsus; metatarsus slightly longer than the remaining segments united; the fourth segment slightly longer than broad; hind tibia five-eighths as long as the tarsus; metatarsus as long as the following segments united; the fourth segment slightly longer than broad. Distance from r to R_5 as great as that from r-m to M_2.

Segments 2 to 5 of abdomen considerably contracted at base, distinctly punctate, punctures growing finer toward the apex; superior processes of last segment acute, prominent, curved; inferior margin of the segment with 3 minute tubercles, second ventral segment with a transverse prominence and a median groove, prominence of third segment bearing a longitudinal fossa, much broadened in front, on its summit, sloping away posteriorly, its anterior face notched at apex.

Genitalia differing from those of *bariscipus* as follows: squama slightly falcate, blunt; sagittae much longer, more slender, and with obtusely rounded apex; sagitta more slender.

Type.—American Entomological Society.

Arizona: Quartzite, April 14, 1903, 8 ♂ (G. S. Hutson), [American Entomological Society]; Phoenix, 1 ♂ [American Entomological Society].

Pseudomasaris (Holopticus) bariscipus, n. sp.

Figures 77 and 85

♂. Black, following parts chestnut to Sanford brown; segments 3 to 7 of antenna at base above, club of antenna except at base beneath, apices of mandibles, anterior tibia except base on outer side, anterior tarsus, middle femur infuscated apically, middle tibia except spot at base on outer side, middle tarsus, hind leg except coxa, narrow median apical border of first dorsal segment, second dorsal segment except for three yellow spots, third dorsal segment except for three yellow spots and three black areas, median apical band on fourth segment, second and third ventral segments, and area on apex of seventh dorsal segment; the following pale chalcedony yellow: spots on mandibles, large spot on clypeus, inner orbits fused above, apex of scape, of third antennal segment above, bases of fifth, sixth, and seventh segments below, base of antennal club beneath, narrow line behind the eyes, humeri broadly, tegulae, large spot on pleura, one median and two anterior spots on mesonotum, preapical spot on scutellum, angles of propodeum, spot on front, and small spot on middle knees, broad band on first segment, 3 transverse spots on second and third, and a sinuate line near apex of fourth, fifth, and sixth dorsal segments, band on fourth ventral and three spots on fifth ventral segments; wings stained slightly yellowish, veins, ferruginous to brown.

Emargination of the eyes narrow, obtuse; front convex but not prominent; clypeus gibbous, front and clypeus closely but shallowly punctate with few large punctures; labial palpi with 2 segments, the second with its apical portion contracted but not discrete. Scape short, subglobular; third segment linear, shorter than fourth; this much widened and pubescent at apex; fifth and sixth segments also clavate but less strongly than the fourth, seventh segment companuliform, nearly twice as long as wide, club ovate, nearly as long as segments 6 and 7.

Mesonotum moderately coarsely and closely punctate, depressed area more closely punctate, disk of scutellum closely and more finely punctate, angles of propodeum acute but not mucronate.

Distance between r and R_5 in excess of that between r-m and M_2. Anterior tarsus ciliate; femora and tibiae all regular, without uneven surfaces; middle tibia flattened beneath, seen from above gradually widened in middle; middle tibia about two-thirds as long as the tarsus; metatarsus nearly as long as the following segments united; fourth

segment about as long as broad; hind tibia five-eighths as long as the tarsus; metatarsus as long as the following segments united; fourth segment slightly longer than broad.

Second ventral segment with two blunt tubercles; process of third segment compressed, with a narrow groove on its summit and two anterior teeth, posteriorly it ends in a tooth directed caudad; last dorsal segment with 2 anterior processes sharp, the 2 apical ones very small and close together.

Squama obtuse, rather densely ciliate on the inner side and also exteriorly at apex; sagitta trigonal, its angles carinate, its apex acute, about one-half as long as the uncus; uncus slender, shorter than in *texanus* and less decurved.

Holotype.—♂, American Entomological Society.

Arizona: Quartzite, April 14, 1903, 8 ♂ (George S. Hutson), [American Entomological Society].

Pseudomasaris (Holopticus) phaceliae Rohwer

1912. *Pseudomasaris phaceliae* Rohwer, ♂, ♀. Proceedings United States National Museum, vol. 41, p. 450.

"♂. Length about 13 mm. Labrum obtusely pointed; clypeus strongly uniformly convex, arcuately emarginate in apical middle, finely punctured; front with rather large, separate punctures; scape not one and a half times as long as broad, third joint distinctly shorter than fourth; anterior ocellus large, subreniform; pronotum polished, with well-separated small punctures; mesonotum with distinct, well-separated punctures, which are somewhat closer in the depressed area; mesopleura and scutellum similarly punctured; propodeum normal; abdomen polished, with widely separated punctures which become smaller posteriorly; seen from above the first dorsal is arcuately emarginate anteriorly; second, third, and fourth dorsal segment depressed basally by about one-third the length of the entire segment; processes of the third ventral and apical segments essentially as in *texanus;* second cubital on the radius slightly longer than the distance between the recurrent veins. Black except where mentioned; apical half of scape, flagellum (except apical spots on fourth and fifth joints and greater part of club), face above level of antennae (the lower margin has three indentations of black), most of clypeus, pronotum, large circular spot below tegulae, tegulae, spot above, two fan-shaped spots on anterior part of mesoscutum and a small spot in front depression, spot on scutellum and angles of propodeum yellow; abdomen with broad dorsal and ventral bands on apex of all segments reddish yellow (due in part to potasium cyanide?); legs reddish-yellow, knees yellowish; wings vitreous, hyaline, slightly yellowish in stigmal region; venation pale brown."

♀. Black except as follows: antennae rufo-piceous; posterior orbits dorsally, narrow line on inner orbits up to and filling the eye emargination, large spot on clypeus, spot above, posterior margin of pro-

notum narrowly, and an elongate lateral spot, large spot below tegulae, tegulae, spot above, large spot in front of depression on mesonotum, most of scutellum, angles of propodeum, dorsal and ventral (except first) abdominal segments apically yellow; pronotum (except where mentioned), band on scutellum, elongate spots on second, third, and fourth segments rufous; legs rufous; wings dusky, especially near the veins; stigma and costa reddish brown, veins dark brown.

Clypeus convex, broadly emarginate, very finely granular, with large punctures intermingled; front with large distinct punctures, which are more widely separated on the eye margins and vertex; hind ocelli equidistant from the eyes and from each other; scape short, third segment of antenna as long as the three following.

Pronotum with well separated large punctures; mesonotum with punctures the size of those of pronotum, but closer and especially so in the depressed area; mesopleura more closely punctured than the mesonotum; scutellum punctured like mesopleura, with an indistinct carina medially.

Second cubital cell on the radius as long as two-thirds of the distance between the recurrent veins.

Abdomen with well separated, distinct punctures, which become smaller posteriorly; first dorsal segment slightly emarginate anteriorly when seen from above; second and third dorsal segments depressed basally for about one-third their length; apical ventral segments with the large punctures well separated. Length, 12 mm.

Types.—Holotype, ♂: U. S. National Museum, no. 14143. Allotype: U. S. National Museum.

New Mexico: Albuquerque, May 13, 1910, ♂ on *Phacelia neomexicana* (J. R. Watson), [type, U. S. National Museum]; Mesilla, May 29, ♀ on flowers of *Phacelia* (T. D. A. Cockerell), [U. S. National Museum]; Fillmore Cañon, ♀ (T. D. A. Cockerell), [U. S. National Museum].

Pseudomasaris (Holopticus) maculifrons Fox

♀ black, the following parts chestnut to Sanford brown: mandibles at tip, antenna beyond the fourth segment, legs, apex of first dorsal segment except for 3 yellow spots, median apical band on second dorsal segment enclosing a yellow bar, narrow median band on third and fourth segments, and the wing veins; the following pale chalcedony yellow: large spot on clypeus above, triangular spot on front, emarginations of eyes, line behind eyes, humeral angles, narrow line along posterior border of pronotum, outer half of tegulae, large spot on pleura, small spots on mesonotum touching tegulae, preapical spot on scutellum, two narrow lines on postscutellum (absent on type), propodeal angles, 3 transverse bars on first and second dorsal segments, sinute subapical band on third, fourth, and fifth dorsal segments, widened laterally, lateral spots on sixth dorsal segment, transverse interrupted and obscure band on second and third ventral segments

(only 2 lateral spots on second segment of type), transverse band occupying most of fourth ventral segment (in type 2 lateral and 2 median spots).

Front closely punctured, clypeus closely and minutely punctulate, with scattered larger punctures, posterior ocelli as far from each other as from the compound eyes.

Humeri rounded; pronotum with well separated coarse punctures; mesonotum with close coarse punctures, posteriorly finer, closer and less regular causing surface to be chagreened; scutellum similarly punctured but with coarse punctures more scattered; pleura a little more densely punctate than pronotum.

Abdominal segments densely punctate at base, punctures finer towards apex of abdomen; second and third segments slightly contracted at their bases. Length, 10 mm.

Description drawn from a specimen from Arizona.

Holotype.—California Academy of Sciences.

Lower California: El Paraiso [Cal. Acad. Sci.].

Arizona: Quartzite, April 14, 1903, 1 ♀ (G. S. Hutson), [American Entomological Society].

Pseudomasaris (Holopticus) basirufus Rohwer

1912. *Pseudomasaris zonalis basirufus* Rohwer, ♀. Proceedings United States National Museum, vol. 41, p. 452.

♀. Black, the following parts straw yellow: spot on mandibles, trilobed spot on clypeus, narrow line around the eyes, interrupted below the incision, mesad of the summits and posteriorly below, triangular spot on sides and narrow posterior border of pronotum, superior spot on pleura, tegulae, small spot near posterior border of mesonotum, apical spot on scutellum, spot on angles of propodeum, apex of front femora and extreme base of their tibiae externally, small spot on apex of middle femora, spot at base of middle tibiae, lengthened laterally, small anterior stripe at base of posterior tibiae, apical stripe on each side of first and second tergite, preapical mesal stripe on same, narrow apical border of third, fourth, and fifth tergites, incised laterally, broadly interrupted stripe of sixth tergite, preapical spots on second and fifth, and apical bands on third and fourth sternites; the following parts burnt sienna: flagellum except base, all of legs except yellow spots and bases of coxae, apical third to two-thirds of first three tergites, excluding yellow portions, first and second sternites and trace on third; wings slightly smoky, slightly violaceous, the veins castaneous to black.

Front closely punctured, punctures more sparse toward the eyes; clypeus finely closely punctulate, the yellow spot indistinctly so. Humeri rounded; pronotum with separated punctures; mesonotum closely, granularly punctate, more finely on the flattened posterior part; scutellum granularly punctate, more densely in the middle than on the sides; sides of propodeum mucronate, not carinate. Abdominal

segments evently and finely, rather densely, punctate; bases of second and third segments somewhat contracted. Length, 9 mm.

Type.—U. S. National Museum, no. 14146.

California: Death Valley, April, 1891, 1 ♀ (A. Koebele), [type, U. S. National Museum].

Arizona: Quartzite, April 14, 1903, 3 ♀ (G. S. Hutson), [American Entomological Society].

Subgenus **Pseudomasaris** Ashmead

1902. *Pseudomasaris* Ashmead. Canadian Entomologist, vol. 34, p. 221.

♂. Eyes never as close together as the distance between the hind ocelli, these not touching the eyes; the temple narrow but distinct; incision of the eye sometimes subacute but usually broadly rounded at apex; front with a low tubercle between and slightly above the bases of the antennae; clypeus slightly or strongly convex, broadly emarginate anteriorly. Antennae as long or longer than the head and thorax united; scape subglobular; pedicel about one-third its length; segments 3 to 6 cylindrical or compressed and somewhat widened at their apices, the third always linear, the seventh slightly or strongly widened, sometimes more than twice as long as wide; segments 4 to 7 in one species flat beneath; club short, not or but slightly exceeding the length of the sixth and seventh segments, ovate, convex above and below or, as in one species, hollowed beneath.

Humeri entirely rounded or more or less prominent; parapsidal furrows absent; angles of propodeum dentate or only sharply carinate.

Anterior leg not contorted; surfaces of the segments uniform; femur and tibia more or less flattened beneath; tarsus in one species ciliate; middle femur with its undersurface convex and regular or contorted and concave; tibia with its undersurface convex and regular or dilated, contorted and concave, but both segments never with uniform undersurfaces in the same species; middle tibia from two-thirds to four-fifths as long as the tarsus; metatarsus two-thirds to three-quarters as long as the remaining segments together; fourth segment as broad as long or almost so; hind tibia from .6 to .8 as long as the tarsus; metatarsus without an apical lobe, approximately equal to the remaining segments united, fourth segment longer than broad.

Basal abdominal segments considerably contracted above at their bases; abdomen much decurved at apex, the last segment with its apical surface truncate, the truncature margined with 2 superior sharp or obtuse prominences and 2 inferior smaller tubercles placed closer together; second ventral segment with 2 low tubercles; process of the third high, posteriorly with an acute tooth directed caudad.

Squama obtuse without setae beneath or with a small patch of bristles; sagitta trigonal, the angles carinate; uncus usually short and blunt but in one species elongate, slender, curved, and acute.

♀. The face without a ridge between the antennae. Humeral angles sometimes subcarinate; angles of propodeum obtuse or dentate. Middle femur usually flattened beneath, sometimes ridged; the basal third of the tibia, seen from in front sometimes distinctly contracted beneath.

Type.—Pseudomasaris occidentalis Cresson (by original designation).

Pseudomasaris (Pseudomasaris) occidentalis Cresson

Figures 19, 62–64, 81

1871. *Masaris occidentalis* Cresson, ♀. Transactions American Entomological Society, vol. 3, p. 348.

1872. *Masaris occidentalis* Cresson, ♂. *Loc. cit.*, vol. 4, p. 231.

1902. *Pseudomasaris occidentalis* Ashmead. Canadian Entomologist, vol. 34, p. 221.

♂. Color black, the following parts yellow ochre to ochraceous orange: face except at base of antennae, line between these, line including the ocelli, clypeus, labrum, mandibles, line behind the eyes, scape except at base, pedicel, third antennal segment except at sides, antennal club except apical three-quarters beneath and posteriorly, pronotum except the collar and spot in front of tegulae, tegulae, large spot below, 2 small spots on mesonotum anteriorly, most of scutellum, angles of propodeum, legs except coxae, apex of first dorsal segment, second abdominal segment except black area in middle above, third segment except dark, basal, dorsal area, fourth and fifth segments except bases, sixth dorsal except its base, sixth ventral entirely, and a band before the prominences of the seventh dorsal segment.

Emargination of the eyes, narrow, triangular, subacute at apex; hind ocelli removed from the compound eyes by considerably less than their diameter's length; front with an elevation below the anterior ocellus, below this a small longitudinal tubercle, only slightly convex with rather strong and separated punctures; clypeus very strongly convex, the punctures irregularly confluent, weaker toward the apex; labial palpi with two segments, the second segment little over one-half as long as the first, its apical part contracted and almost discrete, forming an incomplete third segment; the segment of the maxillary palpus a little longer than usual, not a mere tubercle. Segments 3 to 6 of antenna not at all enlarged at their apices; the seventh slightly enlarged at apex but more than twice as long as broad; the club oval, convex above and below, a very little longer than segments 6 + 7.

Humeral angles slightly prominent but not at all angled; pronotum rather closely punctate, medially impunctate; mesonotum with coarse and well separated punctures in front, becoming finer and closer as they approach the middle; posterior portion of the mesonotum flattened but not depressed, polished, with minute and scattered punctures; scutellum rather strongly convex, the slight anterior median ridge minutely obscurely punctuate, somewhat shining; angles of the propodeum sharply dentate; pleura coarsely punctate.

Front femur and tibia slightly flattened beneath, their surfaces not irregular, the tarsus ciliate; middle femur with regular and convex inferior surface; the tibia seen from in front with its inferior edge at the basal third strongly dilated and angulate; tibia three-quarters as long as the tarsus; metatarsus seven-tenths as long as the remaining segments together; fourth segment about as long as broad; hind tibia four-fifths as long as the tarsus; the metatarsus as long as the remaining segments united; the fourth segment slightly longer than broad. Radial cross-vein a little less distant from R_4 than is M_{3+4} from M_2 on the borders of the cell R_{4+5}.

First segment of the abdomen seen from above deeply concave; the abdomen closely, rather coarsely punctate at base, sparsely and more minutely at apex; truncate surface of last segment extensive, the superior processes acute, the inferior small blunt tubercles; process of the third ventral segment with a median groove on its summit, anteriorly with 2 blunt teeth.

Squama with a patch of setae on the outside but with only short, appressed and inconspicuous pubescence within; the sagitta short and stout, trigonal, the angles sharp, the apex moderately obtuse; uncus deflexed, contracted just beyond the apex of the sagitta, with a ridge but no barb beneath.

♀. Colored as in the males, except the front is black or mostly so, the mesopleura, metapleura, and propodeum more largely tawny, the mesonotum posteriorly with a medial ferruginous wash. Front and vertex closely, rugosely, behind the ocelli sparsely, punctate; clypeus very coarsely and deeply and densely punctate; mesonotum densely punctate on the flattened but not depressed posterior portion, punctulate but more or less obsoletely so in the middle, and with scattered, coarser punctures; scutellum with a weak median carina at base, subobsoletely punctulate, sides of propodeum sharply mucronate; abdomen opaque, very densely punctured.

Types.—Lectotype, ♀ [American Entomological Society, no. 2098]; allotype [American Entomological Society].

Texas: 2 ♂, 4 ♀ [including types; American Entomological Society]; 2 ♂, 2 ♀ [U. S. National Museum].

Pseudomasaris (Pseudomasaris) marginalis Cresson

Figures 20, 59, 60, 61, 79, 80

1864. *Masaris marginalis* Cresson, ♀. Proceedings of the Entomological Society of Philadelphia, 3:677.

1904. *Pseudomasaris marginalis* Dalle Torre. Genera Insectorum, fasc. 19, p. 8.

♂. Black, markings on body light chalcedony yellow and on the legs and antennae amber yellow, as follows: most of clypeus, large spot above, labrum, mandibles obscurely, inner orbits above the emargination very narrowly, narrow line behind the eyes, tip of scape, third

antennal segment, fourth to seventh antennal segments except a black spot beneath at the apex of each, undersurface of club except two black spots, line on humeri, posterior border of pronotum, tegulae, small spot on angles of propodeum, legs beyond the femora and tips of these, irregular subapical band of first, third, fourth, and fifth dorsal segments; three subapical bands on second and sixth dorsal segments; the sixth and seventh antennal segments and club stained reddish; wings stained with yellow, the veins yellowish.

Posterior ocelli removed from the eye by considerably less than their diameter's length; emargination of the eyes broad, not triangular, broadly rounded at apex; front scarcely depressed beneath the median ocellus, elevated into a weak median tubercle above the bases of the antennae, its surface with separated punctures; clypeus moderately convex, its surface weakly shining, rather obsoletely punctate; labial palpi with 2 segments, the first elongate, the second about one-half as long. Fourth, fifth, and sixth segments of the antenna strongly widened at their apices, the seventh about as wide as long, the fourth and fifth flattened beneath at their apices, the sixth and seventh flattened beneath; the club short, irregularly ovate, equal in length to segments 6 and 7, convex above, slightly hollowed beneath.

Humeri rounded, pronotum laterally with well separated, rather coarse punctures; mesonotum anteriorly similarly punctate, more closely punctured in the middle, posteriorly flattened but not depressed and closely almost rugosely punctate; scutellum closely punctate, moderately convex, posterior angles of propodeum carinate but not dentate; pleura with well separated punctures.

Anterior femur and tibia with regular surfaces, somewhat flattened below, the tarsus not ciliate; middle femur concave and ridged beneath with a prominent tubercle near its apex; middle tibia with regular surface, flattened beneath, as seen from in front gradually widened from base to apex, two-thirds as long as the tarsus; metatarsus approximately equal to the remaining segments united; the fourth segment about as long as broad; hind tibia three-fifths as long as the tarsus; metatarsus equal to the remaining segments united; fourth segment slightly longer than broad. Radial cross-vein distant from R_4 by little less than the distance between M_{3+4} and M_2 on the margins of the cell R_{4+5}.

Punctuation of the abdomen fine and close; the surface between the processes of the last segment hardly truncate; superior process blunt, flattened, the inferior sharp, close together; prominence of third ventral segment with its summit anteriorly flattened.

Exterior surface of squama with a patch of very short, inconspicuous setae, the inner surface glabrous except for a group of 15 or 20 stout spines and a less conspicuous group of 3 or 4; sagitta acute, trigonal, the angles sharp; uncus rather long and slender, decurved and slightly widened at apex, the tip mucronate.

♀. Colored as in the male, except that the face and clypeus are black, with a triangular yellow spot between the antennae, the latter are yellow to ferruginous with most of the club fuscous.

Head closely granular, punctate, clypeus, closely punctulate with minute and coarser punctulations; dorsulum densely punctate. Propodeum with rounded, only slightly prominent angles.

Anterior tibiae short and inflated except at base, the other leg segments with even surfaces.

Dorsal segments much less constricted at their bases than in the male, opaque, and densely minutely punctulate.

The male has not been previously described.

Types.—Holotype, ♀, American Entomological Society, no. 2097. Allotype, ♂, American Entomological Society.

Colorado: 6 ♂, 6 ♀ [including type; American Entomological Society]; 4 ♀ [U. S. National Museum].

New Mexico: June 30, 1902, ♀ (H. L. Viereck), [American Entomological Society].

Pseudomasaris (Pseudomasaris) zonalis Cresson

1864. *Masaris zonalis* Cresson, ♂, ♀. Proceedings Entomological Society of Philadelphia, vol. 3, p. 674.

1904. *Pseudomasaris zonalis* Dalle Torre. Genera Insectorum, fasc. 19, p. 8.

♂. Black, following parts Naples yellow: line entirely surrounding eyes except beneath; clypeus, labrum, mandibles, large spot on front, scape except at base, spot on pedicel, entire flagellum except reddish infuscated area at apex of club, humeri, spot on pronotum below, posterior border of pronotum, tegulae, large spot below, small transverse spot at apex of scutellum, angles of propodeum, spot on anterior and middle femur and trochanter beneath, anterior femur beneath and at apex above, middle and posterior femur at tip, all tibiae and tarsi, the latter reddish at apex, slightly incised subapical stripes on all dorsal segments, spot and truncature of the last dorsal segment, spot on sides of ventral segments 2 to 5.

Posterior ocelli distant from the compound eyes by the length of their diameter; front but slightly impressed beneath the anterior ocellus, raised above the bases of the antennae to a low tubercle, rather closely but weakly punctate; the clypeus moderately convex subobsoletely punctate; labial palpus a single long slender segment without sign of subdivision; the maxillary palpus a very small chitinized bulb. Antennal segments 3 to 5 cylindrical, not widened at their apices, the sixth slightly widened at its apex, the seventh more strongly but longer than wide; the club ovate, a little shorter than the sixth and seventh segments together, strongly convex above and below.

Humeri marked by a feeble ridge; pronotum rather closely punctate; mesonotum densely punctate, the posterior flattened portion more coarsely; scutellum moderately convex, closely punctate; pleura with large separated punctures; angles of the propodeum mucronate.

Under surfaces of anterior femur and tibia flattened, regular; tarsus not with fringe of cilia; middle femur with under surface con-

cave and contorted, as also the middle tibia, the latter with its inferior margin seen from the front inflated medially; middle tibia four-fifths as long as the tarsus; the metatarsus two-thirds as long as the remaining segments united; the fourth segment about as long as broad; hind tibia five-eighths as long as the tarsus; metatarsus nearly equal to the length of the remaining segments; fourth segment longer than broad.

Distance between r and R_4 considerably less than that between M_{3+4} and M_2 on the margin of the cell R_{4+5}.

First dorsal segment, seen from above, with its basal surface plane; abdomen rather finely and closely punctate, superior processes of last segment acute, the inferior, small, acute; surface between, somewhat concave; process of the third ventral segment with its summit anteriorly flattened.

Squama exteriorly with only very short inconspicuous pubescence, a small patch of setae within on the inferior margin; sagitta trigonal, long, slender, very acute, slightly curved; uncus moderately slender, slightly widened before the depressed and deflexed tip; the latter sharply acute.

♀. Colored as in the male except as noted; tip of the mandible dusky; labrum black; yellow on clypeus confined to median bar and two lateral spots; only a spot on scape and third segment of antenna yellow; humeral band confluent with spot below; pronotum, larger apical stripe on scutellum, spot on posterior coxa and more of hind and middle femora, yellow; broader stripe on each dorsal segment, broad apical stripe on second and fourth ventral segments, spots on side of sixth ventral segment yellow.

Hind ocelli little closer than their diameter's length from the compound eyes; front closely, rather coarsely punctate; clypeus shagreened with sparser, shorter, coarser, punctures. Humeri marked by a rather sharp transverse ridge; pronotum densely punctured; mesonotum very densely punctate; scutellum convex and densely punctate. Middle femur with under surface flattened, its lower anterior margin marked by a ridge; middle tibia, seen from in front, with the basal third contracted. Dorsal segments 2, 3, and 4 somewhat depressed basally; dorsal surface of the abdomen opaque, minutely, densely punctate.

Types.—Lectotype: ♂, American Entomological Society, no. 2099. Allotype: American Entomological Society.

Idaho: Craig's Mt., 1 ♂ [American Entomological Society].

Colorado: 2 ♂, 11 ♀ [including types; American Entomological Society]; 3 ♀ [U. S. National Museum]; 3 ♀ (H. H. Smith), [Cornell University].

Utah: Salt Lake City, June 13, 1897, 1 ♂ (H. Skinner), [American Entomological Society].

Nevada: 7 ♂, 3 ♀ [American Entomological Society].

California: Giant Forest, in the Sequoia National Park, 6000-7000 feet elevation, July 21–26, 1907, 3 ♀ (J. C. Bradley), [Cornell Univerity]; Fallen Leaf Lake near Lake Tahoe, 4 ♂, 2 ♀, July 12, 15, 1915 (E. C. Van Dyke, L. S. Rosenbaum), [California Academy of Sciences, Cornell University]; Pyramid Peak, El Dorado Co., 1 ♂,

July 8, 1912, 8000 feet altitude (E. C. Van Dyke), [Calif. Acad. Sci.]; Carrville, Trinity Co., 2 ♀, June 6, 1913 (E. C. Van Dyke), [Calif. Acad. Sci. and Cornell Univ.]; Nash Mine, Trinity Co., 1 ♀, June 13, 1913 (E. C. Van Dyke), [Calif. Acad. Sci.].

Pseudomasaris (Pseudomasaris) coquilletti Rohwer

Figure 6

1911. *Pseudomasaris coquilletti* Rohwer, ♂, ♀. Proceedings United States National Museum, vol. 40, p. 555.

♂. Black, the following parts wax yellow: mandibles except tip, labrum, clypeus, stripe on front broadened at base of antennae, line all around the eyes, stripe on maxillae, antennae (shaded apically with ferruginous, the club dusky beneath), pronotum except anterior stripe and stripe in front of tegulae, greater part of mesopleura, 2 lines on mesonotum, interrupted medially, apical half of scutellum, narrow line on postscutellum, large lateral spot including angles of propodeum, front coxae beneath, trochanters, tibiae except basal spot above, front tibiae (shaded at tip with ferruginous), middle and posterior coxae, trochanters and femora, the latter with basal black stripe above, tibiae and tarsi (the apical segments ferruginous), broad apical stripe on each tergite, that on the first six separated medially from the apical margin by a narrow black stripe, two spots on first sternite and most of rest of the venter; wings stained slightly yellowish, the veins testaceous.

Emargination of eyes narrow, linear, obtuse; posterior ocelli removed from the compound eyes by less than their diameter front with a slight fovea below the anterior ocellus, terminating in a weak tubercle above the base of the antennae, closely and shallowly punctulate, the punctulation larger on the black area; clypeus strongly convex with small scattered punctures; segments 3–5 of antennae cylindrical, scarcely enlarged at their apices, six and seven each widened uniformly from base to apex, not flattened, forming the base of the slender club which is more or less convex above and below; the remaining segments fused, a little truncate at tip, together slightly shorter than segments 6 and 7.

Humeral angles rounded, marking the termination of a weak transverse ridge; pronotum with small sparse punctures; mesonotum very densely, finely, punctate, matte; posterior medial portion slightly flattened, punctate like the rest of mesonotum; mesopleura with scattered punctures; scutellum convex, densely punctate, with a median basal ridge; propodeum laterally alate and sharply dentate, the posterior margins of the alae sinuate; posterior surface of propodeum densely, finely, punctulate, its lateral surfaces impunctate, matte.

Front femur widened at basal third, tibia flattened and somewhat irregular beneath; middle femur with fossa, ridge and nodule beneath; tibia flattened beneath, the undersurface more irregular than that of front pair. Radial cross-vein about as far from R_4 as M_2 is from M_{3+4} on the borders of the cell R_{4+5}.

Second to fourth dorsal segments constricted basally; first segment almost flat basally; tergites densely and very finely punctate in the middle, becoming imperceptibly punctulate laterally and more sparsely but distinctly punctate basally; four processes of last segment acute, the inferior ones smaller and closer together; second sternite raised at base, the raised portion divided by a median longitudinal depressed line; process of third segment with a truncate molar-like anterior surface, posteriorly produced into an acute tooth.

♀. Black; the following parts yellow: mandibles except tip, clypeus except 2 crescent shaped spots, labrum, large triangular spot above clypeus, inner orbits convergent behind the ocelli, broad line behind the eyes, spot on scape and third antennal segment, humeri very broadly, posterior margin of pronotum broadly, tegulae, most of mesopleura, spot on metapleura, 2 longitudinal lines on mesonotum, apical half of scutellum, postscutellum, propodeum except for 2 triangular spots, all coxae and trochanters in front, femora in front and at tips behind; the anterior femur except at base behind, all tibiae and tarsi, broad subapical band on first dorsal segment, incised anteriorly, subapical band on second, third, and fourth, occupying entire segment at sides, fifth dorsal segment, sixth at base, spots on first ventral segment, second ventral segment except at base, third, fourth, and fifth ventral segments, and the sixth except at base and apex; antennal club ferruginous, yellow beneath; third, fourth, fifth, and sixth antennal segments shading from yellow into ferruginous; wings stained yellow; veins, yellow to ferruginous.

Front granular, clypeus finely so, hind ocelli equally distant from each other and from the eyes.

Humeral angles marked by a feeble ridge; dorsum granular, more finely so on the flattened portion of the mesonotum; scutellum granular, with larger scattered punctures; pleura with shallow punctures.

Middle femur flattened beneath, the anterior lower margin with a ridge; the tibia seen from in front gradually widened from base to apex, three-quarters as long as the tarsus; metatarsus nearly as long as the following segments united; posterior tibia three-quarters as long as the tarsus; this slightly exceeding the remaining segments united. The radial cross-vein distant from R_4 by a little over one-half the distance between M_{3+4} and M_2 on the margin of the cell R_{4+5}.

Abdomen opaque, closely punctured dorsally; second and third dorsal segments depressed at base.

Types.—♂, ♀ [U. S. National Museum, no. 13734].

California: Los Angeles Co., April, ♂, ♀ (D. W. Coquillett), [types, U. S. National Museum]; Claremont, ♂, ♀ [Cornell University]; Southern California, 4 ♀ [American Entomological Society]; Sierra Nevada, 2 ♀ [American Museum of Natural History]; Soboba Springs, Riverside Co., 2 ♀, June 1, 1917, on *Eriodyction crassifolium* (E. P. Van Duzee), [California Academy of Sciences]; Southern Sonoma Co., 1 ♂, April 16, 1911 (J. A. Kusche), [California Academy of Sciences].

Mr. Van Duzee informs me that he observed 4 specimens at Soboba Springs, all visiting Yerba Santa, *Eriodyction crassifolium*, but was able to collect only two of these.

Subgenus **Cotyledon**, new subgenus

♂. Eyes more remote from each other than the distance between the hind ocelli, these not touching the eyes; emargination of the eye moderately narrow, the apex rounded; front with a median prominence above the base of the antennae; clypeus much broader than long, convex, deeply emarginate anteriorly; labial palpi of 2 segments, the second less than one-half the length of the first and indistinctly discrete therefrom; maxillary palpi a very minute, scarcely chitinized, bulb bearing one heavy seta and 2 more slender ones.

Scape globose; pedicel about one-third its length; segment 3 cylindrical; segment 4 a little longer, slightly and suddenly widened before its apex; segment 5 slightly gradually widened; segment 6 greatly widened toward its apex, nearly as wide as long, apical portion concave beneath and forming part of the club; the seventh segment about 3 times as wide as long; the remaining segments fused, together about as long as the sixth and seventh segments; the club formed of the sixth, seventh, and remaining segments, strongly concave beneath and with the shape of a partly closed hand.

Undersurfaces of front and middle femora and tibiae concave, contorted, and tuberculate; middle tibia and tarsus about equal in length; metatarsus as long as the remaining segments united; the fourth segment much broader than long; hind tibia about three-quarters as long as the tarsus; the metatarsus about equal to the remaining segments united, without an apical lobe; the 4th segment about as broad as long. Distance between r and R_4 equal to one-third the distance between M_{3+4} and M_2 on the margin of the cell R_{4+5}.

Basal abdominal segments considerably constricted; the last dorsal segment without a definitely truncate apical area but with 4 acute processes of which the inferior are the larger, closer together and slightly closer to the superior processes than to each other; second ventral segment with two rounded tubercles; the third with a prominent transverse ridge replacing the ordinary process, armed with a sharp median tooth directed caudad.

The squama densely ciliate within; sagitta short, trigonal, acute, the upper margin very deeply triangularly notched; uncus slender, deflexed, with two small barbs at base.

♀. Posterior ocelli about equidistant from the eyes and each other; eyes broadly emarginate. Humeri fitting closely around the head and marked by a prominent ridge; posterior angles of propodeum mucronate. Middle femur seen from in front, with its inferior margin sinuate, slightly inflated in the middle; middle tibia, from an external view distinctly inflated at about the middle, about three-quarters as long as the tarsus; metatarsus as long as the following segments united; fourth segment nearly as long as broad; hind tibia nearly three-quarters as long as the tarsus; metatarsus about as long as the remaining segments together; the fourth segment as long as broad.

The radial cross-vein opposite R_5 or separated therefrom by a distance not greater than that between r-m and M_{3+4}. Dorsal segments 2, 3, and 4 slightly depressed at base.

Type.—Masaris edwardsii Cresson.

Pseudomasaris (Cotyledon) edwardsii Cresson

Figures 10, 31–33, 78, 108

1872. *Masaris edwardsii* Cresson, ♂, ♀. Transactions American Entomologic Society, vol. 4, p. 87.

1904. *Pseudomasaris edwardsi* Dalle Torre. Genera Insectorum, fasc. 19, p. 8.

♂. Black; the following parts mustard yellow: clypeus, labrum, mandibles, except tips, large spot on front, interior orbits, line behind the eyes, antenna except stripe on segments 3 to 5 above, and posterior part of the club above, humeri, spot below, posterior border of the pronotum, tegula, large spot below, narrow subapical line on scutellum interrupted medially, two small basal spots on propodeum, propodeal angles, spot below, spot on all coxae, anterior and middle trochanters beneath, anterior and middle femora except above at base, posterior femur at apex, extending nearly to the base in front, all tibiae and metatarsi, subapical band on first dorsal segment, three subapical bars on second, subapical band deeply incised on third and fourth, apical half of fifth, two-thirds of sixth, and half of seventh dorsal segment, except tubercles, band on second ventral segment, on the third, apical two-thirds of the fourth, fifth entirely banded, and irregular marks on sixth; wings hyaline, slightly infuscated in the cell 2d $R_1 + R_2$; veins ferruginous.

Front densely but rather finely punctate with an obsoletely punctate tubercle above the antennae, strongly depressed before the base of the clypeus; this obsoletely punctate, moderately convex.

Pronotum closely and rather coarsely punctate, mesonotum densely punctate, the posterior portion flattened with coarser and confluent punctuation; scutellum slightly convex, anteriorly finely, posteriorly more coarsely punctate; pleura with separated punctures.

Anterior femur with a median tubercle and ridge beneath; the posterior margin of the tibia seen from above, sinuate; tarsi depressed and broad, without a prominent fringe of cilia, segments 2 to 4 very short and broad; middle femur irregularly concave, carinate, and tuberculate beneath; middle tibia contorted, concave, and irregularly carinate beneath and in front, the anterior margin from an external view with a strong median tooth, the apex with a group of short spines in front; hind femur with a brush of dark hairs beneath at base, the surface slightly irregular.

Abdomen rather finely densely punctate; tubercles of the second ventral segment polished and shining; the surface of the fourth, fifth, and sixth ventral segments short tomentose.

Squama blunt, the inner surfaces with long coppery ciliae; uncus about two-thirds the length of the squama, slender, acute, deflexed.

♀. Coloration differing from the male as follows: labrum and two bars on the clypeus black, yellow spot on scape and segments 3 and 4 of the antenna; humeral stripe broader, confluent with spot below; pleural spot much larger; a spot on metapleura, two lines on mesonotum, apical half of scutellum, propodeum entirely except for posterior V-shaped black band, yellow; anterior coxa and trochanter and most of middle trochanter black; middle and posterior coxa yellow in front, more of posterior femur yellow; broad apical band on each dorsal segment, that on first bearing two black spots; spot on first ventral, most of second ventral, broad apical bands on following three segments, and two large spots on sixth ventral segment, yellow.

Front and clypeus granular. Humeri fitting closely behind the head, marked by a distinct transverse ridge; pronotum closely punctate; mesonotum densely punctate, posterior flattened part granular; scutellum slightly convex, finely granular; propodeal angle ending in a rather long spine. Abdomen opaque, densely, closely punctate.

Types.—Lectotype, ♂: American Entomological Society, no. 2096. Allotype, ♀: American Entomological Society.

Utah: Logan Cañon, July 24, 1906, 1 ♂ (Dr. P. B. Homer), [Cornell University].

Nevada: 3 ♂, 6 ♀ [American Entomological Society].

California: Felton, Santa Cruz Mts., May 20–25, 1907, 2 ♂, 3 ♀, between 300 and 500 feet elevation (J. C. Bradley), [Cornell University]; Claremont, 1 ♂, 3 ♀ (C. F. Baker), [Pomona College and Cornell University]; 3 ♂, 3 ♀ [including types, American Entomological Society]; Fallen Leaf Lake near Lake Tahoe, 2 ♂, 2 ♀, June 29 and July 11 and 12, 1915 (E. C. Van Dyke), [California Academy of Sciences and Cornell University]; Carrville, Trinity Co., 2 ♀, June 6, 29, 1903 (E. C. Van Dyke), [California Academy of Sciences].

Washington: Cheney, June 30, 1908, and May, 1906, 2 ♀ [Cornell University].

A number of specimens of this species were taken by the author on different days within a very short area along an abandoned, overgrown road leading south from the residence of Mr. Trotz at Felton, California. They were flying leisurely over grass, close to the ground.

Trimeria Saussure

Figures 23, 38, 39, 53–55, 84, 105

1912. *Trimeria* Zavattari. Archiv für Naturgeschichte, vol. 78, pt. A, no. 2, p. 58. Redescription.

♂. Head transversely quadrate; the temples narrow, margined posteriorly, rectangular below; eyes triangularly emarginate, the apex of the incision slightly obtuse, distant from one another above; the ocelli in an equilateral triangle; vertex prominent; front nearly flat, without tubercles; clypeus slightly convex, shield-shaped, its anterior margin broadly shallowly emarginate; mandibles broad, obliquely tridentate toward the apex; ligula elongate and retractile; labial palpus completely 3-segmented; maxillary palpus reduced to a transparent, very short, conical tubercle. Antenna much shorter than the thorax, of 12 distinct segments, not clavate but the flagellum slightly fusiform; scape long, cylindrical, pedicel less than one-third as long, remaining segments short, as broad or broader than long, the seventh to the tenth dilated a little mesally beneath.

Dorsal surface of pronotum anteriorly transversely margined; parapsidal furrows wanting; tegula small, oval, not covering the base of the scutellum, the outer margin not sinuate, or scarcely so; scutellum rather flat, in some species posteriorly margined with a reflexed rim overhanging the postscutellum; posterior surface of propodeum sloping, the angles mucronate.

Forewing not plaited, R_5 absent, the cells R_4 and R_5 therefore coalesced; m-cu attached to Cu_1, which from that point turns downward to meet M_4. Anterior trochanter armed at apex with a process with two upturned lamellate edges; anterior femur with its posterior inferior edge somewhat angled and sinuate; middle femur flattened beneath; tibiae with regular surfaces; anterior tibial spur strongly curved, slender, acute; middle tibia with a single apical spur; larger posterior tibial spur bifid at apex; tarsal claws simple.

Abdomen sessile, the basal dorsal segment squarely truncate at base, the apical segment short, hoodlike, strongly decurved toward and weakly notched at the apex; second and third ventral segments unarmed; last ventral segment with its apical border truncate.

Squama ending in an upturned acute hook, a tubercle on the inner side apicad of the sagitta, which is reduced to a larger tubercle borne on the inner side of the squama; uncus very broad and flat, obtuse, beneath with two long sharp barbs at base.

I have not seen a female.

Type.—Trimeria americana Saussure, genus monobasic.

Habitat.—Brazil and Argentina.

List of Species

americana Saussure, ♀. Brazil.

1853. *Erynnis americana* Saussure. ♀. Bull. Société Entomologique de France, (3) I, p. xx, n. 2.
(3) I, p. xx, n. 2.

buyssoni Brethes, ♂, ♀. Argentine, Paraguay.

1904. *Trimeria buyssoni* Brethes, ♀. Anales del Museo nacional de Buenos Aires, (3), vol. 2, p. 371.

1905. *Trimeria buyssoni* Du Buysson, ♂. Bulletin de la Société Entomologique de France, 1905, p. 10.

1912. *Trimeria buyssoni* Zavattari, ♂, ♀. Archiv für Naturgeschichte, vol. 78, pt. A, no. 2, p. 59.

howardi Bertoni. Argentina.

1912. *Trimeria howardi* Bertoni. Anales del Museo national de Buenos Aires, (3), vol. 22, p. 104.

joergenseni Schrottky, ♂, ♀. Argentina.

1909. *Trimeria joergenseni* Schrottky, ♀. Revista del Museo del la Plata, vol. 16, p. 137.

1910. *Trimeria joergenseni* Brethes, ♂. Anales del Museo nacional de Buenos Aires, vol. 20, p. 285.

1912. *Trimeria joergenseni* Zavattari, ♂, ♀. Archiv für Naturgeschichte, vol. 78, pt. A, no. 2, p. 59.

neotropica (Moesarya) Du Buysson, ♂, ♀.

1906. *Jugurtia neotropico* Moesarya, ♂. Annales Histoico-Naturales Musei Nationalis Hungarici, vol. 4, p. 197.

1910. *Trimeria neotropica* Du Buysson, ♂. Zoologische Jahrbücher, Abt. für Syst., vol. 49, p. 241.

1912. *Trimeria neotropica* Zavattari, ♂, ♀. Archiv. für Naturgeschichte, vol. 78, pt. A, no. 2, p. 60.

Key to the Species

Zavattari, Edoardo. Archiv für Naturgeschichte, 1912, pt. A, no. 2, p. 59.

EXPLANATION OF PLATES

PLATE 2

Fig. 1. *Euparagia scutellaris* Cresson, ♀.

Fig. 2. *Euparagia scutellaris* Cresson, ♂.

Fig. 3. *Paragia decipiens* Shuckard, ♂.

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PLATE 3

Fig. 4. *Gayella eumenoides* Spinola, ♂.
Fig. 5. *Masariella alfkeni* (Du Buysson), ♂.
Fig. 6. *Pseudomasaris coquilletti* (Rohwer), ♂.
Fig. 7. *Celonites abbreviatus* (Villers), ♂.
Fig. 8. *Paraceramius lusitanicus* (Klug), ♂.
Fig. 9. *Ceramius fonscolombei* Latreille, ♂.

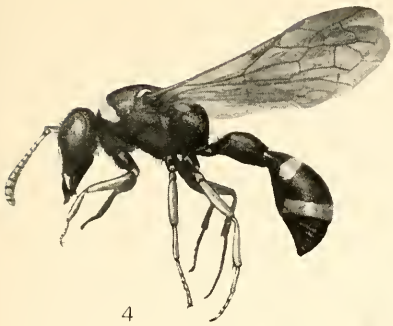

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PLATE 4

Fig. 10. *Pseudomasaris edwardsii* (Cresson). Genitalia.
Fig. 11. *Euparagia scutellaris* Cresson. Genitalia.
Fig. 12. *Ceramius fonscolombei* Latreille. Genitalia.
Fig. 13. *Paragia tricolor* Smith. Trophi, ♀.
Fig. 14. *Euparagia scutellaris* Cresson. Trophi.
Fig. 15. *Ceramius fonscolombei* Latreille. Trophi.

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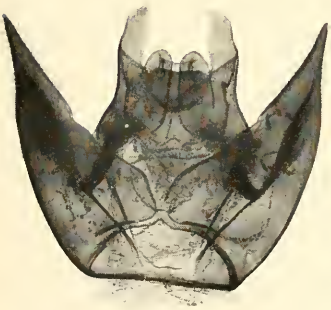

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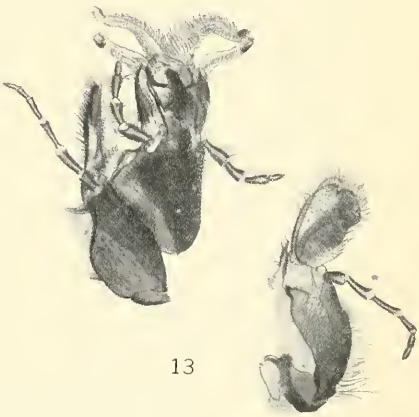

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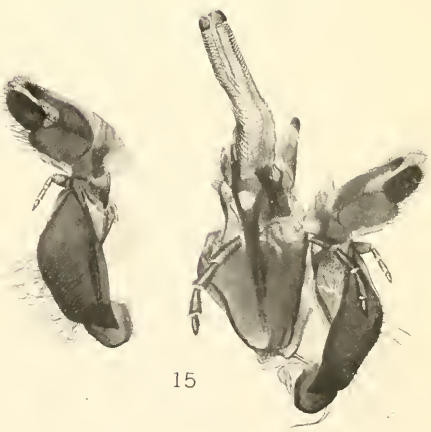

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PLATE 5

Fig. 16. *Paraceramius lusitanicus* (Klug). Trophi.

Fig. 17. *Paraceramius lusitanicus* (Klug). Central portion of tongue, much enlarged.

Fig. 18. *Masaris vespiformis* Fabricius. Trophi.

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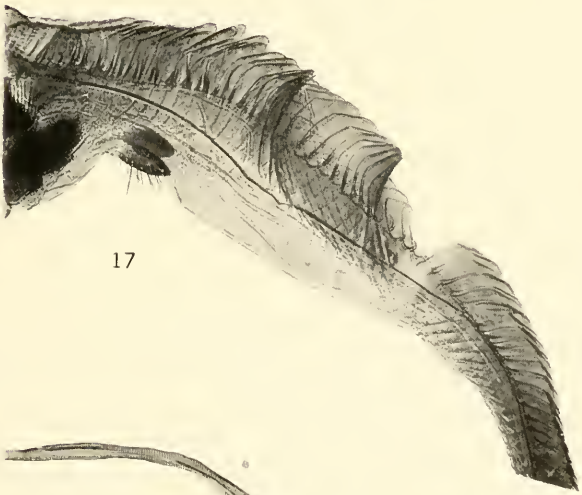

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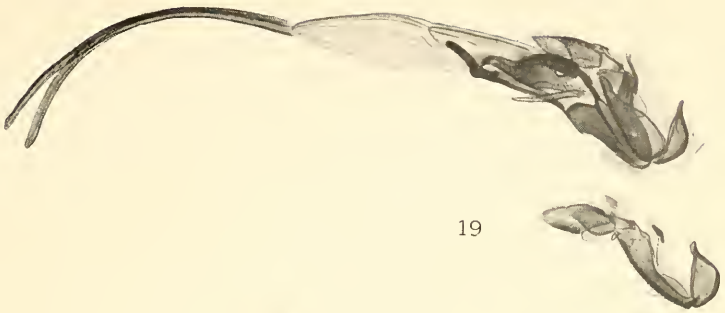
PLATE 6

Fig. 19. *Pseudomasaris occidentalis* (Cresson). Trophi.

Fig. 20. *Pseudomasaris marginalis* (Cresson). Trophi, the tongue retracted.

Fig. 21. *Pseudomasaris vespoides* (Cresson). Trophi.



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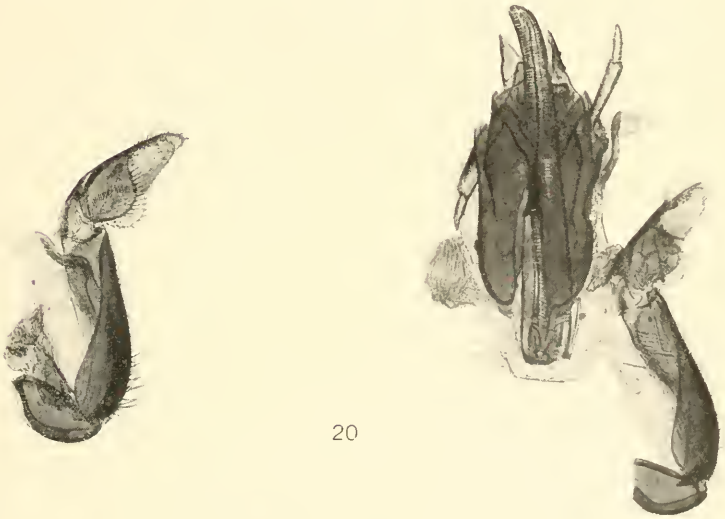

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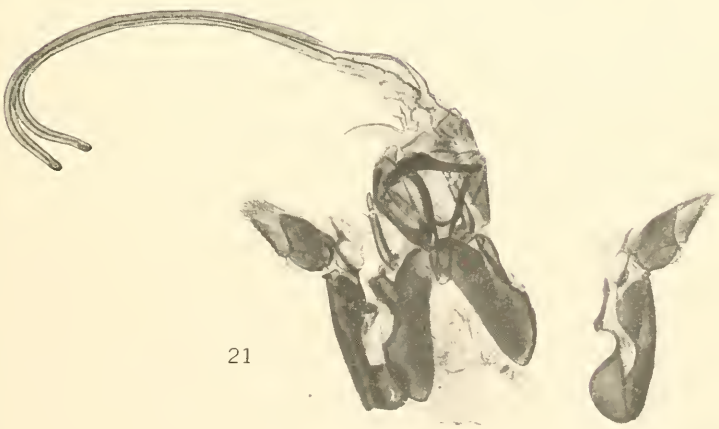

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PLATE 7

Fig. 22. *Celonites abbreviatus* (Villers). Trophi.
Fig. 23. *Trimeria buyssoni* Brethes. Trophi.

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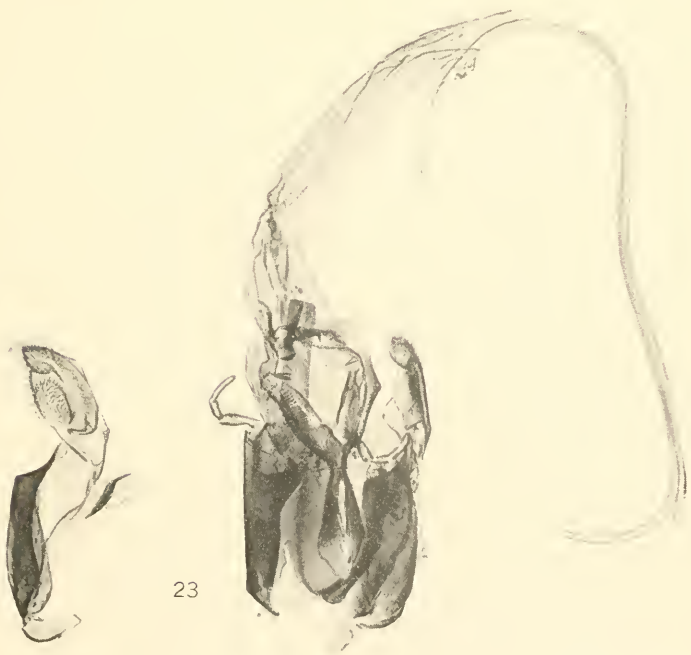

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PLATE 8

Fig. 24. *Paragia decipiens* Shuckard. Right tegula.

Fig. 25. *Paragia decipiens* Shuckard. Right lateral view of scutellum and postscutellum.

Fig. 26. *Euparagia scutellaris* Cresson. Right lateral view of scutellum and postscutellum.

Fig. 27. *Euparagia scutellaris* Cresson. Right tegula.

Fig. 28. *Masaris vespiformis* Fabricius. Lateral view of right side of posterior part of thorax and first abdominal segment.

Fig. 29. *Masaris vespiformis* Fabricius. Dorsal view of right side of posterior part of thorax and first abdominal segment.

Fig. 30. *Masaris vespiformis* Fabricius. Left tegula.

Fig. 31. *Pseudomasaris edwardsii* (Cresson). Right lateral view of scutellum and postscutellum.

Fig. 32. *Pseudomasaris edwardsii* (Cresson). Dorsal view of scutellum and postscutellum.

Fig. 33. *Pseudomasaris edwardsi* (Cresson). Right tegula.

Fig. 34. *Celonites abbreviatus* (Villers). Right lateral view of thorax and basal segment of abdomen.

Fig. 35. *Celonites abbreviatus* (Villers). Dorsal view of thorax and basal segment of abdomen.

Fig. 36. *Ceramioides capicola* (Brauns). Right lateral view of scutellum and postscutellum.

Fig. 37. *Paraceramius lusitanicus* (Klug). Left tegula.

Fig. 38. *Trimeria buyssoni* Brethes. Right lateral view of scutellum and postscutellum.

Fig. 39. *Trimeria buyssoni* Brethes. Right tegula.

Fig. 40. *Masariella alfkeni* (Du Buysson). Left lateral view of posterior part of thorax and first abdominal segment.

Fig. 41. *Masariella alfkeni* (Du Buysson). Left tegula.

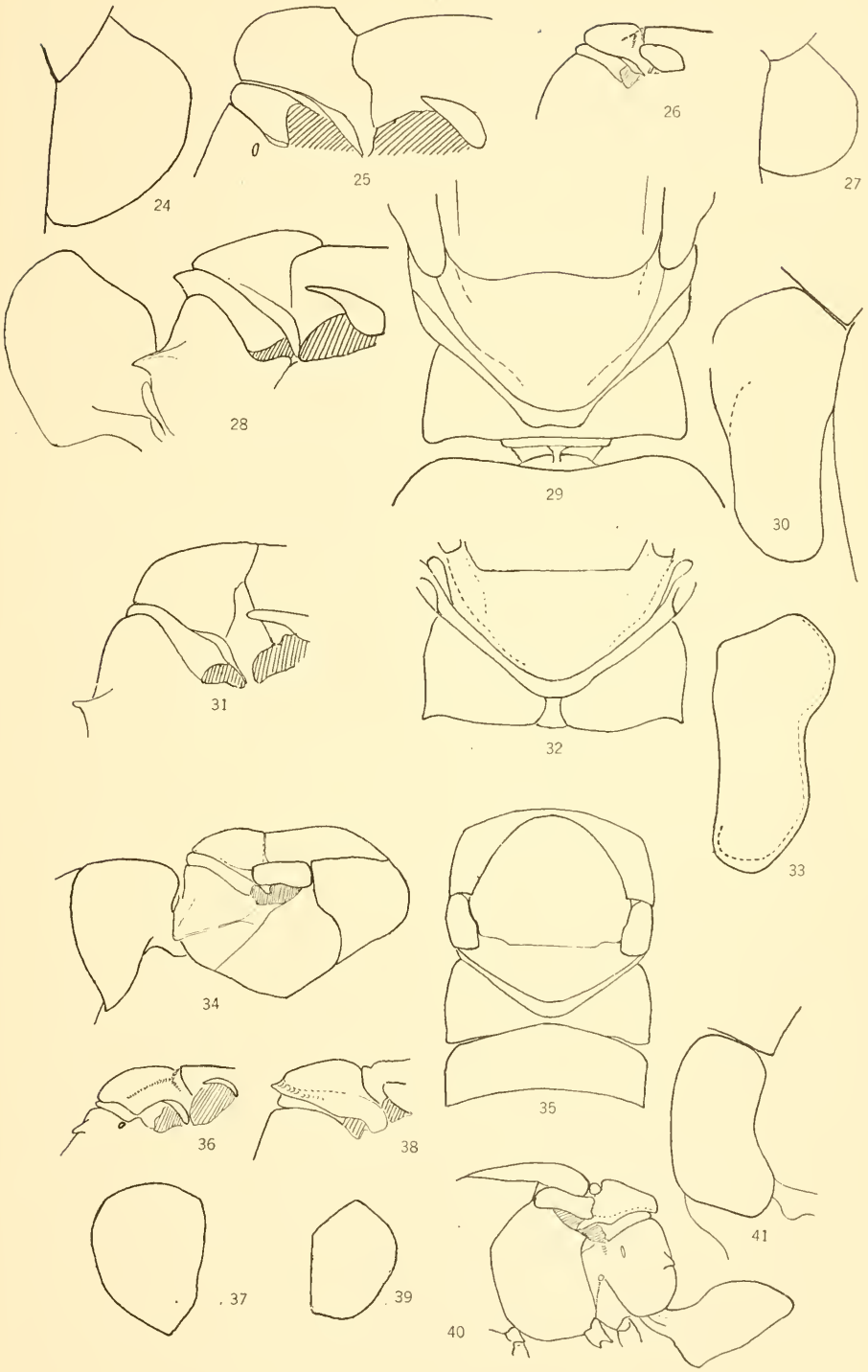
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PLATE 9

Fig. 42. *Euparagia scutellaris* Cresson. Genitalia, dorsal view.
Fig. 43. *Paragia tricolor* Smith. Genitalia, dorsal view.
Fig. 44. *Paragia tricolor* Smith. Genitalia, ventral view.
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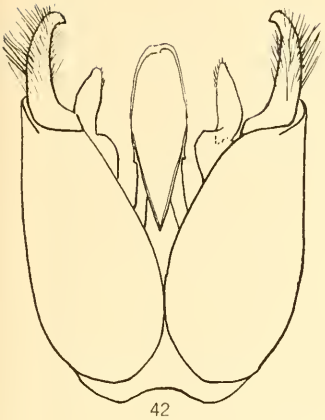
Fig. 52. *Celonites abbreviatus* (Villers). Genitalia, dorsal view.



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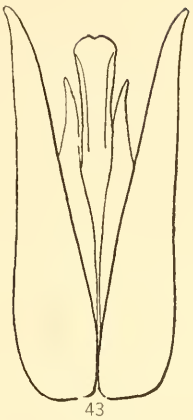

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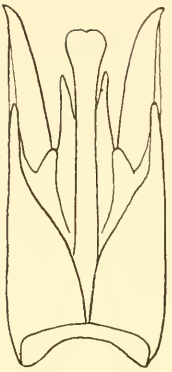

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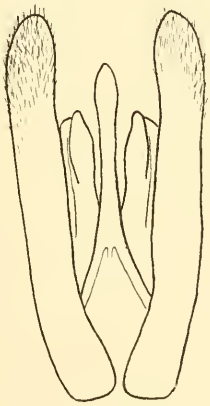

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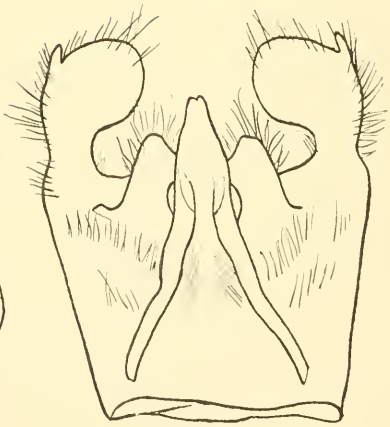

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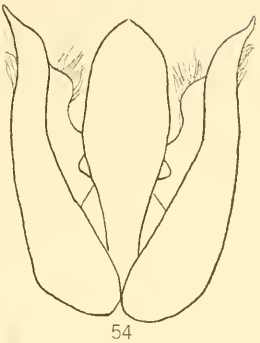
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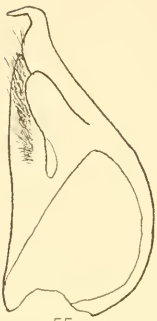
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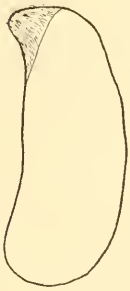
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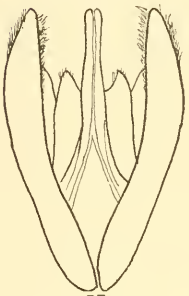
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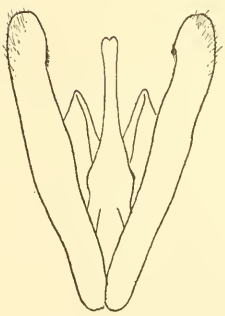
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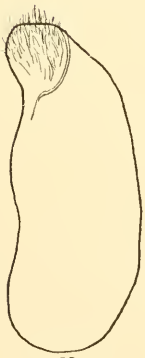
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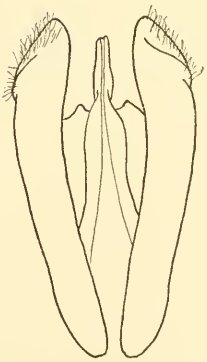
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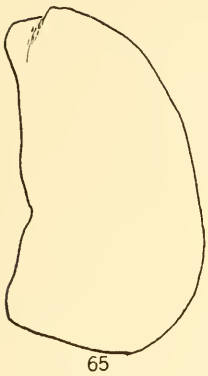
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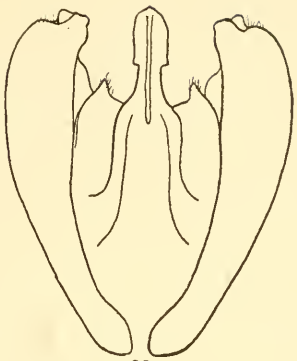
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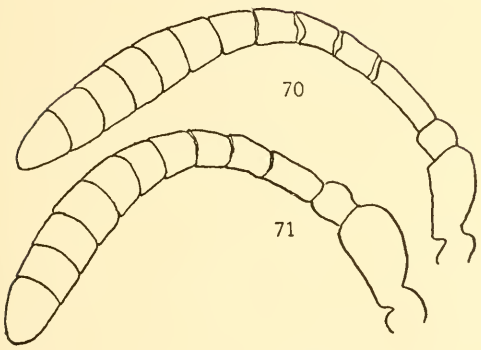
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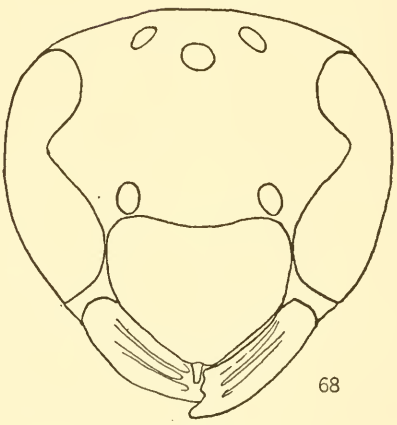
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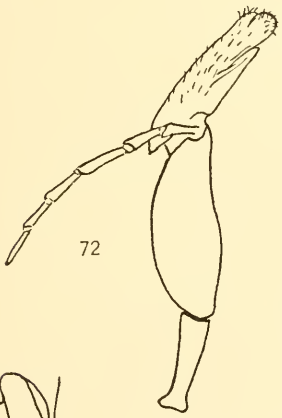
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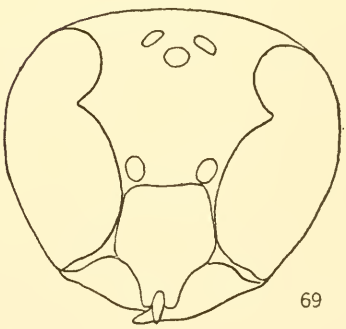
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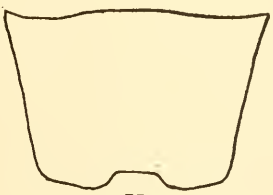
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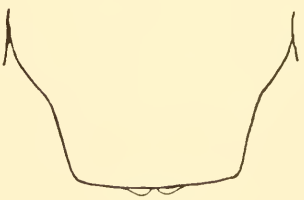
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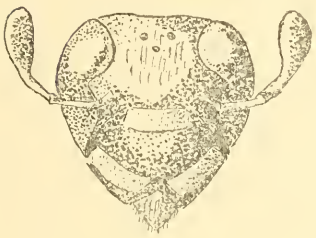

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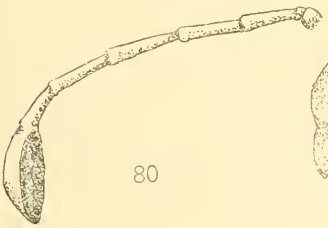

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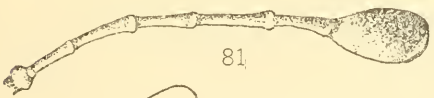

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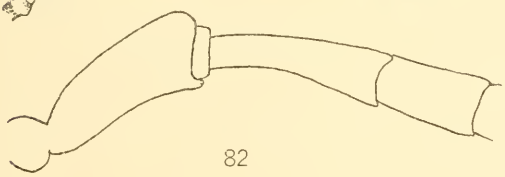

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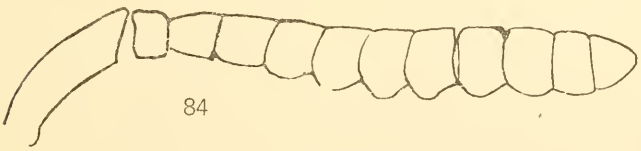

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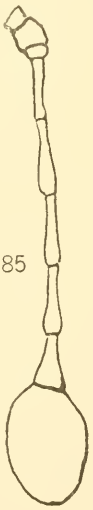

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Fig. 97. *Gayella eumenoides* Spinola. Wings.

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Fig. 98. *Mischocyttarus labiatus.* Wings. Veins labeled: *p. l.*, posterior lobe; *ax. exc.*, axillary excision.

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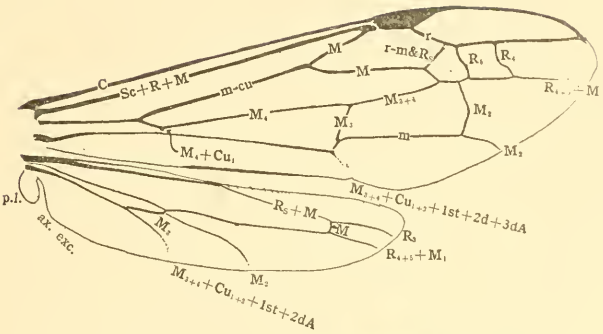
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Sc+R+M
m-cu
M
r
r-m&R5
R5
R4
M
M3+4
M4
M3
M2
m
M1+Cu1
M2
M3+4+Cu1+2+1st+2d+3dA
p.l.
ax. exc.
M3
R5+M
M
R3
R4+5+M1
M3+4+Cu1+2+1st+2dA
M2

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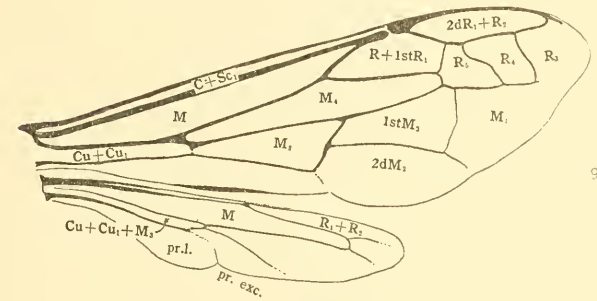
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R+1stR1
R5
R4
R3
C+Sc1
M4
M
1stM3
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Cu+Cu1+M3
pr.l.
pr. exc.

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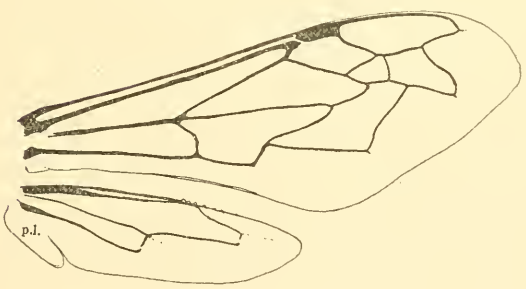
p.l.

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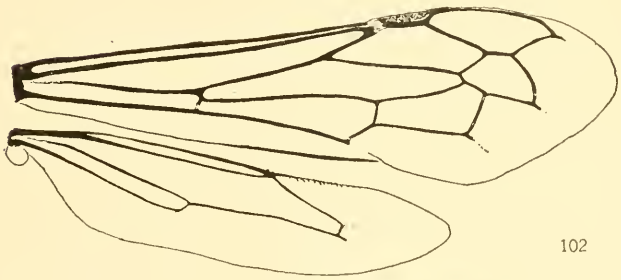

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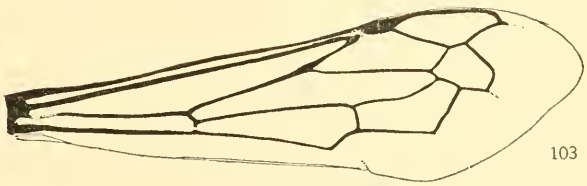

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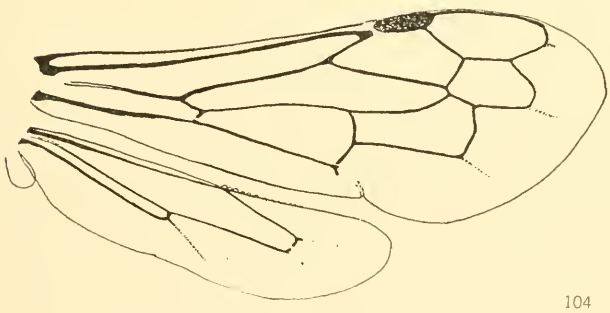

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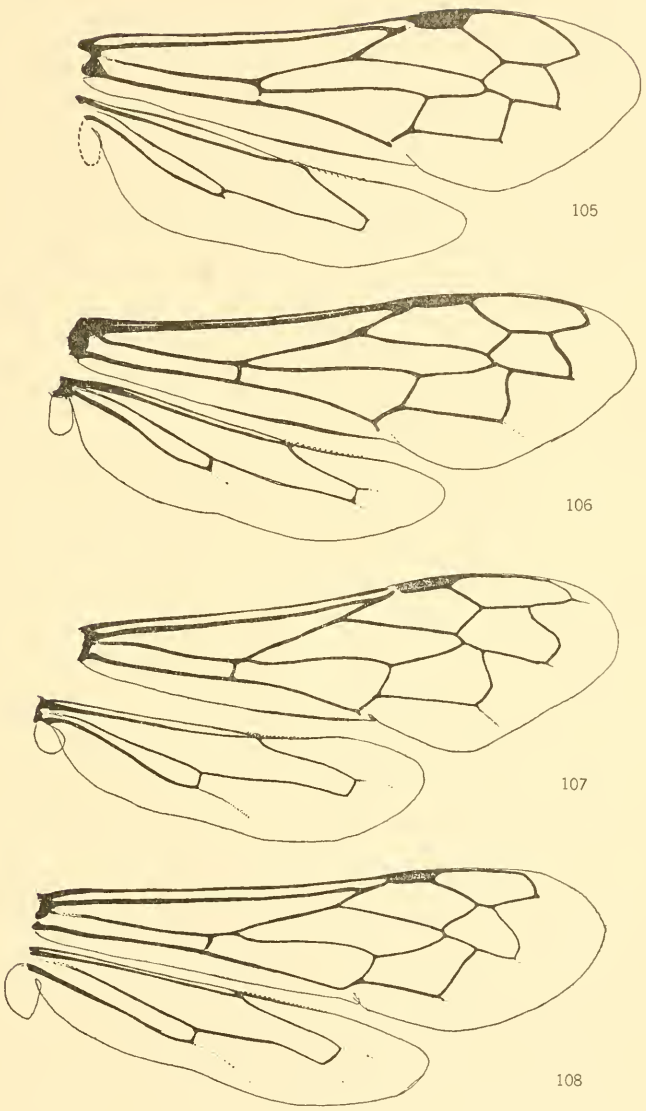

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